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(57) Abstract

A method for killing pests (e.g. insects) comprising administering material from *Xenorhabdus* species (e.g. *X. nematophilus*) such as cells or supernatants orally to the pests, either alone or in conjunction with *Bacillus thuringiensis* or pesticidal materials derived therefrom. Also disclosed is an isolated pesticidal agent (and compositions comprising the same) characterised in that it is obtainable from cultures of *X. nematophilus* or mutants thereof, has oral pesticidal activity against *Pieris brassicae*, *Pieris rapae* and *Plutella xylostella*, is substantially heat stable to 55 °C, is proteinaceous, acts synergistically with *B. thuringiensis* cells as an oral pesticide and is substantially resistant to proteolysis by trypsin and proteinase K. DNA encoding pesticidal activity is also disclosed.

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PESTICIDAL AGENTS

The present invention relates to materials, agents and compositions having pesticidal activity which derive from bacteria, and more particularly from *Xenorhabdus* species. The invention further relates to organisms and methods employing such compounds and compositions.

There is an ongoing requirement for materials, agents, compositions and organisms having pesticidal activity, for instance for use in crop protection or insect-mediated disease control. Novel materials are required to overcome the problem of resistence to existing pesticides. Ideally such materials are cheap to produce, stable, have a high toxicity (either when used alone or in combination) and are effective when taken orally by the pest target. Thus any invention which provided materials, agents, compositions or organisms in which any of these properties was enhanced would represent a step forward in the art.

Xenorhabdus spp. in nature are frequently symbiotically associated with a nematode host, and it is known that this association may be used to control pest activity. For instance, it is known that certain *Xenorhabdus spp.* alone are capable of killing an insect host when injected into the host's hemocoel.

In addition, one extracellular insecticidal toxin from *Photorhabdus luminescens* has been isolated (this species was recently removed from the genus *Xenorhabdus*, and is closely related to the species therein). This toxin is not effective when ingested, but is highly toxic when injected into certain insect larvae (see Parasites and Pathogens of Insects Vol.2, Eds. Beckage, N. E. et al., Academic Press 1993).

Also known are certain low-molecular weight heterocyclic compounds from *P.luminescens* and *X.nematophilus* which have antibiotic properties when applied intravenously or topically (see Rhodes, S.H. et al., PCT WO 84/01775).

Unfortunately none of these prior art materials have the ideal pesticide characteristics discussed above, and in particular, they do not have toxic activity when administered orally.

The present invention provides pesticidal agents and compositions from *Xenorhabdus* species, organisms which produce such compounds and compositions, and methods which employ these agents, compositions and organisms, that alleviate some of the problems with the prior art.

According to one aspect of the present invention there is disclosed a method of killing or controlling insect pests comprising administering cells from *Xenorhabdus* species or pesticidal materials derived or obtainable therefrom, orally to the pests.

A PCT application of CSIRO published as WO 95/00647 discloses an apparently toxic protein from *Xenorhabdus nematophilus*; however no details of the protein's toxicity are given, and certainly there is no disclosure of its use as an oral insecticide.

Thus the invention provides an insecticidal composition adapted for oral administration to an insect, which composition comprises a pesticidal material obtainable from a *Xenorhabdus* species, or a pesticidal fragment thereof, or a pesticidal variant or derivative of either of these.

The composition may in fact comprise cells of *Xenorhabdus* or alternatively supernatant taken from cultur s of cells of *Xenorhabdus* species. However, the composition

preferably comprises toxins isolable from *Xenorhabdus* as illustrated her inafter. Toxic activity has be n associated with material encoded by the nucleotide sequ nce of Figure 2. Thus, the composition suitably comprises a pesticidal material which is encoded by all or part of the nucleotide sequence of Figure 2. Pesticidal fragments as well as variants or derivatives of such toxins may also be employed.

The sequence of Figure 2 is of the order of 40kb in length. It is believed that this sequence may encode more than one protein, each of which may regulate or be insecticidal either alone or when presented together. It is a matter of routine to determine which parts are necessary or sufficient for insecticidal activity.

As used herein the term ``variant'' refers to toxins which have modified amino acid sequence but which share similar activity. Certain amino acids may be replaced with different amino acids without altering the nature of the activity in a significant way. The replacement may be by way of ``conservative substitution'' where an amino acid is replaced with an amino acid of broadly similar properties, or there may be some non-conservative substitutions. In general however, the variants will be at least 60% homologous to the native toxin, suitably at least 70% homologous and more preferably at least 90% homologous.

The term ``derivative'' relates to toxins which have been modified for example by chemical or biological methods.

These toxins are novel, and they and the nucleic acids which encode them form a further aspect of the invention.

A preferred *Xenorhabdus* species is the bacteria *X.nematophilus*. Particular strains of *X.nematophilus* which are us ful in the context of the inv ntion are

ATTC 19061 strain, available from the National Collection of Industrial and Marine Bacteria, Aberdeen, Scotland (NCIMB). In addition, suitable strains include two novel strains of *Xenorhabdus* which were deposited at the NCIMB on 10 July 1997 and were designated with repository numbers NCIMB 40886 and NCIMB 40887. These latter strains form a further aspect of the invention.

All strains have common characteristics as set out in the following Table 1.

Table 1

Characteristics	Strains ATCC 19061	NCIMB 40887	NCIMB 40886
Gram strain	negative	negative	negative
Shape/size	rods up to 4µm long	rods up to 4µm long	rods up to 4µm long
Motile	Yes	Yes	Yes
Bioluminescent	No	No	No
Colour on NBTA*	blue	blue	blue
insecticidal on ingestion by insects	yes	yes	yes
Production of Antibiotics	yes	yes	yes
Resistant to ampicillin (50µg/ml)	yes	yes	yes
colony morphology/ colour	circular convex cream	circular convex cream	circular convex cream

*NBTA (Oxoid nutrient agar containing 0.0025% bromothymol blue and 0.004% tetrazolium chloride)

Preferably the pest target is an insect, and more preferably it is of the order Lepidoptera, particularly

Pieris brassicae, *Pieris rapae*, or *Plutella xylostella* or the order *Diptera*, particularly *Culex quinquefaciatus*.

In a preferred embodiment of the invention, cells from *Xenorhabdus* species or agents derived therefrom are used in conjunction with *Bacillus thuringiensis* as an oral pesticide.

In further embodiments, rather than using *Bacillus thuringiensis* itself, pesticidal materials obtainable from *B.thuringiensis* (e.g. delta endotoxins or other isolates) are used in conjunction with *Xenorhabdus* species.

The term 'obtainable from' is intended to embrace not only materials which have been isolated directly from the bacterium in question, but also those which have been subsequently cloned into and produced by other organisms.

Thus the unexpected discovery that bacteria of the genus *Xenorhabdus*(and materials derived therefrom) have pesticidal activity when ingested, and that such bacteria and materials can be used advantageously in conjunction with *B.thuringiensis* (and toxins or materials derived therefrom), forms the basis of a further aspect of the present invention. The pesticidal activity of *B.thuringiensis* isolates alone have been well documented. However, synergistic pesticidal activity between such isolates and bacteria of the *Xenorhabdus* species (or materials derived therefrom) has not previously been demonstrated.

In still further embodiments of the invention, culture supernatant taken from cultures of *Xenorhabdus* species, particularly *X. nematophilus*, is used in place of cells from *Xenorhabdus* species in the methods above.

All of these methods can be employed, inter alia, in pest control.

The invention also makes available pesticidal compositions comprising cells from *Xenorhabdus* species, preferably *X.nematophilus*, in combination with *B. thuringiensis*. As with the methods above, a pesticidal toxin from *B.thuringiensis* (preferably a delta endotoxin) may be used as an alternative to *B.thuringiensis* in the compositions of the present invention

Likewise, culture supernatant taken from cultures of *Xenorhabdus* species, preferably, *X.nematophilus* may be used in place of cells from *Xenorhabdus* species.

Such compositions can be employed, *inter alia*, for crop protection eg. by spraying crops, or for livestock protection. In addition, compositions of the invention may be used in vector control.

The invention further encompasses novel pesticidal agents which can be isolated from *Xenorhabdus spp*. Techniques for isolating such agents would be understood by the skilled person.

In particular, such techniques include the separation and identification of toxin proteins either at the protein level or at the DNA level.

The applicants have cloned and partially sequenced a region of DNA from *Xenorhabdus* NCIMB 40887 which region codes for insecticidal activity and this is shown as Figure 2 (SEQ ID NO. 1) hereinafter. Thus in a preferred embodiment the invention also provides a toxin which is encoded by DNA of SEQ ID No. 1 or a variant or fragment thereof.

The invention also provides a recombinant DNA which encodes such a toxin. The recombinant DNA of the invention may comprise the sequence of Figure 2 or a variant or fragment thereof. Other DNA sequences may encode similar proteins as a result of the degeneracy of the genetic code. All such sequences are encompassed by the invention.

The sequence provided herein is sufficient to allow probes to be produced which can be used to identify and subsequently to extract DNA of toxin genes. This DNA may then be cloned into vectors and host cells as is understood in the art.

DNA which comprises or hybridises with the sequence of Figure 2 under stringent conditions forms a further aspect of the invention.

The expression ``hybridises with'' means that the nucleotide sequence will anneal to all or part of the sequence of Figure 2 under stringent hybridisation conditions, for example those illustrated in ``Molecular Cloning'', A Laboratory Manual'' by Sambrook, Fritsch and Maniatis, Cold Spring Habor Laboratory Press, Cold Spring Harbor, N.Y.

The length of the sequence used in any particular analytical technique will depend upon the nature of the technique, the degree of complementarity of the sequence, the nature of the sequence and particularly the GC content of the probe or primer and the particular hybridisation conditions employed. Under high stringency, only sequences which are completely complementary will bind but under low stringency conditions, sequences which are 60% homologous to the target sequence, more suitably 80% homologous, will bind. Both high and low stringency conditions are encompassed by the term ``stringent conditions'' used herein.

Suitable fragments of the DNA of Figure 2, i.e. those which encode pesticidal agents may be identified using standard techniques. For example, transposon mutagenesis techniques may be used, for example as described by H.S. Siefert et al., Proc. Natl. Acad. Sci. USA, (1986) 83, 735-739. Vectors such as the cosmid cHRIMI, can be mutated using a variety of transposons and then screened for loss of insectidal activity. In this way regions of DNA encoding proteins responsible for toxic activity can be identified.

For example, the mini-transposon mTn3(HIS3) can be introduced into a toxic *Xenorhabdus* clone such as cHRIM1, hereinafter referred to as `clone 1', by electroporating cHRIM1 DNA into *E.coli* RDP146(pLB101) and mating this strain with *E.coli* RDP146(pOX38), followed by *E. coli* NS2114Sm. The final strain will contain cHRIM1DNA with a single insertion of the transposon mTn3(HIS3). These colonies can be cultured and tested for insecticidal activity as described in Example 8 hereinafter. Restriction mapping or DNA sequencing can be used to identify the insertion point of mTn3(HIS3) and hence the regions of DNA involved in toxicity. Similar approached can be used with other transposons such as Tn5 and mTn5.

Site directed mutagenesis of cHRIM1 as outlined in ``Molecular Cloning, A Laboratory Manual'' by Maniatis, Fritsch and Sambrook, (1982) Cold Spring Harbor, can also be used to test the importance of specific regions of DNA for toxic activity.

Alternatively, subcloning techniques can be used to identify regions of the cloned DNA which code for insecticidal activity. In this method, specific smaller fragments of the DNA are subcloned and the activity determin d. To do this, cosmid DNA can be cut with a suitable restriction enzyme and ligated into a compatible

restriction site on a plasmid vector, such as pUC19. The ligation mix can be transformed into *E. coli* and transformed clones selected using a selection marker such as antibiotic resistance, which is coded for on the plasmid vector. Details of these techniques are described for example in Maniatis et al, supra, (see p390-391) and Methods in Molecular Biology, by L.G. Davies, M.D. Dibner and J.F. Battey, Elsevier, (see p222-224).

Individual colonies containing specific cloned fragments can be cultured and tested for activity as described in Example 8 hereinafter. Subclones with insecticidal activity can be further truncated using the same methodology to further identify regions of the DNA coding for activity.

The invention also discloses an isolated pesticidal agent characterised in that the agent is obtainable from cultures of *X. nematophilus* or variants thereof, has oral pesticidal activity against *Pieris brassicae, Pieris rapae* and *Plutella xylostella*, is substantially heat stable to 55°C, is proteinaceous, acts synergistically with *B.thuringiensis* cells as an oral pesticide and is substantially resistant to proteolysis by trypsin and proteinase K.

By 'substantially heat stable to 55°C' is meant that the agent retains some pesticidal activity when tested after heating the agent in suspension to 55°C for 10 minutes, and preferably retains at least 50% of the untreated activity.

By 'substantially resistant to proteolysis' is meant that the agent retains some pesticidal activity when exposed to proteases at 30°C for 2 hours and preferably retains at least 50% of the untreated activity.

By 'acts synergistically' is meant that the activity of the combination of compon nts is greater than one might expect from the use of the components individually. For example, when used in conjunction with *B.thuringiensis* cells as an oral pesticide, the concentration of B. thuringiensis cellular material necessary to give 50% mortality in a P.brassicae when used alone is reduced by at least 80% when it is used in combination the agent at a concentration sufficient to give 25% mortality when the agent is used alone.

It has been found that the activity of the material is retained by 30 kDa cut-off filters but is only partly retained by 100 kDa filters.

Preferably the agent is still further characterised in that the pesticidal activity is lost through treatment at 25°C with sodium dodecyl sulphate (SDS - 0.1% 60 mins) and acetone (50%, 60 mins).

Clearly the characterising properties of the isolated agent described above can be utilised to purify it from, or enrich its concentration in, *Xenorhabdus* species cells and culture medium supernatants. Methods of purifying proteins from heterogenous mixtures are well known in the art (eg. ammonium sulphate precipitation, proteolysis, ultrafiltration with known molecular weight cut-off filters, ion-exchange chromatography, gel filtration, etc.). The oral pesticidal activity provides a convenient method of assaying the level of agent after each stage, or in each sample of eluent. Such methodology does not require inventive endeavour by those skilled in the art.

The invention further discloses oral pesticidal compositions comprising one or more agents as described above. Such compositions preferably further comprise other pesticidal materials from non-*Xenorhabdus* species.

These other materials may be chosen such as to have complementary properties to the agents described abov , or act synergistically with it.

Preferably the oral pesticidal composition comprises one or more pesticidal agents as described above in combination with *B. thuringiensis* (or with a toxin derived therefrom, preferably endotoxin).

Recombinant DNA encoding said proteins also forms a further aspect of the invention. The DNA may be incorporated into an expression vector under the influence of suitable control elements such as promoters, enhancers, signal sequences etc. as is understood in the art. These expression vectors form a further aspect of the invention. They may be used to transform a host organism so as to ensure that the organism produces the toxin.

The invention further makes available a host organism comprising a nucleotide sequence coding for a pesticial agent as described above.

Methods of cloning the sequence for a characterised protein into a host organism are well known in the art. For instance the protein may be purified and sequenced: as activity is not required for sequencing, SDS gel electrophoresis followed by blotting of the gel may be used to purify the protein. The protein sequence can be used to generate a nucleotide probe which can itself be used to identify suitable genomic fragments from a *Xenorhabdus* gene library. These fragments can then be inserted via a suitable vector into a host organism which can express the protein. The use of such general methodology is routine and non-inventive to those skilled in the art. Such techniques may be applied to the production of *X norhabdus* toxins other than those encoded by the sequence of Figure 2.

It may be desirable to manipulate (eg. mutate) the agent by altering its gene sequence (and hence protein structure) such as to optimise its physical or toxicological properties.

It may also be desirable for the host to be engineered or selected such that it also expresses other proteinaceous pesticidal materials (eg. delta- endotoxin from *B. thuringiensis*). Equally it may be desirable to generate host organisms which express fusion proteins composed of the active portion of the agent plus these other toxicity enhancing materials.

A host may be selected for the purposes of generating large quantities of pesticidal materials for purification e.g. by using *B.thuringiensis* transformed with the agent-coding gene. Preferably however the host is a plant, which would thereby gain improved pest-resistance. Suitable plant vectors, eg. the Ti plasmid from *Agrobacterium tumefaciens*, are well known in the art. Alternatively the host may be selected such as to be directly pathogenic to pests, eg. an insect baculovirus.

The teaching and scope of the present invention embraces all of these host organisms plus the agents, mutated agents or agent-fusion materials which they express.

Thus the invention makes available methods, compositions, agents and organisms having industrially applicable pesticidal activity, being particularly suited to improved crop protection or insect-mediated disease control.

The methods, compositions and agents of the present invention will now be described, by way of illustration only, through reference to the following non-limiting examples and figures. Other embodiments falling within

the scope of the invention will occur to those skilled in the art in the light of these.

FIGURE

Figure 1 shows the variation with time of the growth of *X. nematophilus* ATCC 19061 and activity of cells and supernatants against *P. brassicae* as described in Example 3.

Figure 2 shows the sequence of a major part of a cloned toxin gene from *Xenorhabdus*.

Figure 3 shows a comparison of the restriction maps of cloned toxin genes from two strains of *Xenorhabdus* (clone 1 above and clone 3 below).

EXAMPLES

Example 1 - Use of *X. nematophilus* cells as an oral insecticide

CELL GROWTH: A subculture of *X.nematophilus* (ATCC 19061, Strain 9965 available from the National Collections of Industrial and Marine Bacteria, Aberdeen, Scotland) was used to inoculate 250 ml Erlenmeyer flasks each containing 50 ml of Luria Broth containing 10g tryptone, 5g yeast extract and 5g NaCl per litre. Cultures were grown in the flasks at 27°C for 40hrs on a rotary shaker.

PRODUCTION OF CELL SUSPENSION: Cultures were centrifuged at 5000 x g for 10 mins. The supernatants were discarded and the cell pellets washed once and resuspended in an equal volume of phosphate buffered saline (8g NaCl, 1.44g Na_2HPO_4 and 0.24g of KH_2PO_4 per litre) at pH 7.4.

ACTIVITY OF CELL SUSPENSION TO INSECTS: The bioassays were as follows: *P. brassicae*: The larvae were allowed to feed on an artificial agar-based diet (as described by David and Gardiner (1965) London Nature, 207, 882-883) into which a series of dilutions of cell suspension had been incorporated. The bioassays were performed using a series of 5 doses with a minimum of 25 larvae per dose. Untreated and heat-treated (55°C for 10 minutes) cells were tested. Mortality was recorded after 2 and 4 days with the temperature maintained at 25°C.

	LC50 cells/g diet	
Treatment	2 days	4 days
Untreated	5.9×10^5	9.8×10^4
Treated 55°C	7.1×10^5	1.4×10^5

Aedes aegypti: The larva were exposed to a series of 5 different dilutions of cell suspension in deionised water. The biosassays were performed using 2 doses per dilution of 50 ml cell suspension in 9.5cm plastic cups with 25 second instar larvae per dose. Untreated and heat-treated (55°C or 80°C for 10 minutes) cells were tested. Mortality was recorded after 2 days with the temperature maintained at 25°C.

	LC50 cells/ml
Treatment	2 days
Untreated	5.1×10^6
Treated 55°C	7.4×10^6
Treated 80°C	$> 10^8$

Culex quinquefaciatus: The larvae were exposed to a single concentration cell suspension containing 4×10^7 cells/ml. The biosassays were performed using 2 50 ml cell suspensions in 9.5 cm plastic cups with 25 second instar larvae per cup. Untreated and heat-treated (55°C or 80°C for 10 minutes) cells were tested. Mortality was

recorded after 2 days with the temperature maintained at 25°C.

Treatment	% Mortality 2 days
Untreated	100
Treated 55°C	100
Treated 80°C	0

Thus these results clearly show that cells from *X. nematophilus* are effective as an oral insecticide against a number of insect species (and are particularly potent against *P.brassicae*). The insecticidal activity is not dependent on cell viability (i.e is largely unaffected by heating to 55°C which reduces cell viability by >99.99%) but is much reduced by heating to 80°C, which denatures most proteins.

Example 2 - Use of *X.nematophilus* supernatant as an oral insecticide

CELL GROWTH: Cultures were grown as in Example 1.

PRODUCTION OF SUPERNATANT: Cultures were centrifuged twice at 10000g for 10 mins. The cell pellets were discarded.

ACTIVITY OF SUPERNATANT TO INSECTS: The Bioassay was as follows:
Activity against neonate *P. brassicae* and two day old *Pieris rapae* and *Plutella xylostella* larvae was measured as for *P. brassicae* in Example 1, but using a series of untreated dilutions of supernatant in place of of cell supensions and with mortality being recorded after 4 days only.

Insect species	LC50 (µl supernatant/g diet) 4 days
P. brassicae	22
P. rapae	79
P. xylostella	135

In addition, size-reducing activity (62% reduction in 7 days) against *Mamestra brassicae* was detected in larvae fed on an artificial diet containing *X. nematophilus* supernatant (results not shown).

Thus these results clearly show that the supernatant from *X. nematophilus* culture medium is effective as an oral insecticide against a number of insect species, and are particularly potent against *P. brassicae*.

The heating of supernatants to 55°C for 10 minutes caused a partial loss of activity while 80°C caused complete loss of activity. Activity was also completely lost by treatment with SDS (0.1%w/v for 60 mins) and Acetone (50% v/v for 60 mins) but was unaffected by Triton X-100 (0.1% 60 mins), non-diet P40 (0.1% 60 mins), NaCl (1 M for 60 mins) or cold storage at 4°C or -20°C for 2 weeks. All of these properties are consistent with a proteinaceous agent.

The general mode of action of *X. nematophilus* cells and supernatants i.e. reduction in larval size and death within 2 days at high dosages, and other properties, eg. temperature resistence, appear to be similar suggesting a single agent or type of agent may be responsible for the oral insecticide activity activities of both cells and supernatants.

Example 3 - Timescale for appearance of ingestable ins cticidal activity

CELL GROWTH: 1ml of an overnight culture of *X. nematophilus* was used to inoculate an Erlenmeyer flask. Cells were then cultured as in Example 1. Growth was estimated by measuring the optical density at 600 nm.

PRODUCTION OF CELL SUSPENSION AND SUPERNATANTS: These were produced as in Examples 1 and 2.

ACTIVITY OF CELLS AND SUPERNATANTS AGAINST *P. BRASSICAE*: The cell suspension bioassay was carried out as in Example 1, but using a single dose of suspended cells equivalent to 50 µl of broth/g diet and measuring mortality after 2 days. The cell supernatant bioassay was carried out as in Example 2, but using a single dose equivalent to 50 µl supernatant/g diet (i.e. more than twice the LC50) and measuring mortality after 2 days.

The results are shown in Fig. 1. Thus these results clearly show that cells taken from *X. nematophilus* culture medium are highly effective as an oral insecticide against *P. brassicae* after only 5 hours, and supernatants are highly effective after 20 hours. Although some slight cell lysis was observed in the early stages of growth, no significant cell lysis was observed after this point demonstrating that the supernatant activity may be due to an authentic extracellular agent (as opposed to one released only after cell breakdown).

Example 4 - Synergy between *X. nematophilus* cells and *B.thuringiensis* powder preparations

CELL GROWTH AND SUSPENSION: *X. nematophilus* cells were grown and suspended as in Example 1. *B. thuringiensis* strain HD1 (from *Bacillus* Genetic Stock Centre, The Ohio State University, Columbus, Ohio 43210, USA) was cultured, harvested and formulated into a powder as described by Dulmage *et al.*(1970) J. Invertebrate Pathology 15, 15-20.

ACTIVITY OF *X. NEMATOPHILUS* CELLS AND *B. THURINGIENSIS* POWDER AGAINST *P. BRASSICAE*: The bioassays was carried out using *X. nematophilus* and *B. thuringiensis* in combination or using *B. thuringiensis* cell powder alone. Bioassays were carried out as in Example 1 but with various dilutions of *B. thuringiensis* powder in place of *X. nematophilus*. For the combination experiment, a constant dose of *X. nematophilus* cell suspension sufficient to give 25% mortaility was also added to the diet. Mortality was recorded after 2 days.

	LC50 (µg Bt powder/g diet)
Bioassay	2 days
B.t. alone	1.7
B.t. plus *X.nematophilus*	0.09

These results clearly demonstrate the synergism between *X. nematophilus* cells and *B. thuringiensis* powder when acting as an oral insecticide against *P. brassicae*.

Example 5 - Synergy between of *X.nematophilus* supernatants and *B. thuringiensis* powder

CELL GROWTH AND PRODUCTION OF SUPERNATANTS: *X. nematophilus* cells were grown and supernatants prepared as in Example 2. *B. thuringiensis* was grown and treated as in Example 4.

ACTIVITY OF *X. NEMATOPHILUS* SUPERNATANTS AND Bt CELL POWDER AGAINST *P. BRASSICAE*:
The bioassays were carried out using *X. nematophilus* supernatants and *B. thuringiensis* in combination or using *B. thuringiensis* powder alone. The Bioassay against neonate *P. brassicae* and two day old *Pieris rapae* and *Plutella xylost lla* larvae w re measured as in Example 2 but with various dilutions of *B. thuringiensis* in place of *X. nematophilus*. For the combination experiment, a

constant dose of *X. nematophilus* supernatant sufficient to give 25% mortality was also added to the diet. Mortality was recorded after 4 days.

	LC_{50} (µg Bt powder/g) diet	
Insect species	Bt alone	Bt plus Xn
P. brassicae	1.4	0.12
P. rapae	2.5	0.26
P. xylostella	7.2	0.63

These results clearly demonstrate the synergism between *X.nematophilus* supernatants and *B.thuringiensis* powder when acting as an oral insecticide against several insect species. The fact that both *X. nematophilus* cells and supernatants demonstrate this synergism strongly suggests that a single agent or type of agent is responsible for the demonstrated activities.

Example 5 - Characterisation of insecticidal agent from *X.nematophilus* supernatant by proteolysis

CELL GROWTH AND PRODUCTION OF SUPERNATANTS: *X. nematophilus* cells were grown and supernatants prepared as in Example 2.

PROTEOLYSIS OF SUPERNATANT: Culture supernatant (50ml) was dialysed against 0.5 M NaCl (3 x 1 l) for 48 hours at 4°C. The volume of the supernatant in the dialysis tube was reduced five-fold by covering with polyethylene glycol 8000 (Sigma chemicals). Samples were removed and treated with either trypsin (Sigma T8253 = 10,000 units/mg) or proteinase K (Sigma P0390 = 10 units/mg) at a concentration of 0.1 mg protease/ml sample for 2 hours at 30°C.

ACTIVITY OF PROTEASE TREATED SUPERNATANT AGAINST *P. BRASSICAE*: The boassay against neonate *P. brassicae*

larvae was carried out by spreading 25 µl of each 'treatment' on the artificial agar-based diet referred to in Example 1 in a 4.5 cm diameter plastic pot. Four pots each containing 10 larvae were used for each treatment. Mortalities were recorded after 1 and 2 days. Controls using water only, trypsin (0.1 mg/ml) and proteinase K (0.1 mg/ml) were also tested in the same way.

	% Mortality	
Treatment	1 day	2 days
Untreated supernatant	60	100
Proteinase K treated supernatant	45	100
Trypsin treated supernatant	40	100
All controls (no supernatant)	0	0

Example 6

Entomocidal activity of other *Xenorhabdus*

Using the methodology of Examples 1 and 2, four different *xenorhabdus* strains were tested against insect pests. The results obtained were as follows:

I) Activity to *Pieris brassicae*

Strain deposit no/code	Cells 10^6/grm diet % mortality	Supernatant LC50 µl/gram of diet
NCIMB 40887	100	0.09
0014	100	0.52
0015	80	3.73
NCIMB 40886	100	0.05

It was found that entomocidal activity of cells and supernatant was reduced by more than 99% when all four strains were heated at 80°C for 10 minutes.

II) Activity to mosquitoes (*Aedes aegypti*)
Bacteria added at the rate of 10^7cells/ml of water

Strain deposit no/code	Cells 10^6/grm diet % mortality
NCIMB 40887	0
0014	40
0015	45
NCIMB 40886	95

Furthermore, all strains significantly reduced the growth of *Heliothis virescens*.

Example 7

Cloning of toxin genes from strains of *Xenorhabdus*

Total cellular DNA was isolated from NCIMB 40887 and ATCC 19061 using a Quiagen genomic purification DNA kit. Cells were grown in L borth (10g tryptone, 5g yeast extract and 5g NaCl per 1) at 28°C with shaking (150rpm) to an optical density of 1.5 A_{600}. Cultures were harvested by centrifugation at 4000xg and resuspended in 3.5mls of buffer B1 (50mM Tris/HCl, 0.05% Tween 20, 0.5% Triton X-100, pH7.0) and incubated for 30 mins at 50°C. DNA was isolated from bacterial lysates using Quiagen 100/G tips as per manufacturers instructions. The resulting purified DNA was stored at -20°C in TE buffer (10mM Tris, 1mM EDTA, pH 8.0).

A representative DNA library was produced using total DNA of NCIMB 40887 and ATTC 19061 partially digested with the restriction enzyme *Sau3a*. Approximately 20µg of DNA from each strain was incubated at 37°C with 0.25 units of the enzyme. At time intervals of 10, 20, 30, 45 and 60 minutes, samples were withdrawn and heated at 65°C for 15 minutes. To visualise the size of the DNA fragments, the samples were electrophoresed on 0.5% w/v agarose gels.

The DNA samples which contained the highest proportion of 30 to 50kb fragments were combined and treated with 4 units of shrimp alkaline phosphatase (Boehringer) for 15 minutes at 37°C, followed by heat treatment at 65°C to inactivate the phosphatase.

The size selected DNA fragments were ligated into the BamH1 site of the cosmid vector SuperCos! (Stratagent) and packaged into the *Escherichia coli* strain XL Blue 1, using a Gigapack II packaging kit (Stratgene) in accordance with the manufacturers instructions.

To select for cosmid clones with entomocidal activity, individual colonies selected on L agar plates containing 25µg/ml ampicillin, were grown in L broth (containing 25µg/ml ampicillin) overnight at 28°C. Broth cultures (50µl) were individually spread onto the surface of insect diet contained in 4.5cm diameter pots, as described in Example 5. To each container 10 neonate *P. brassicae* larvae were added. Larvae were examined after 24, 72 and 96 hours recording mortality and size of surviving larvae. A total of 220 clones of NCIMB 40887 were tested, of which two were found to cause reduction in larval growth and death within 72 hours. Of 370 clones from ATTC 19061, one was found to cause larval death within 72 hours.

Example 8

Activity of cloned toxin genes to *Pieris brassicae*

The three active clones from Example 7 were grown in L broth, containing 25µg/ml ampicillin, for 24 hours at 28°C, on a rotary shaker at 150rpm. The activity of the toxin clones to neonate larvae were performed by incorporation of whole broth cultures into insect diet, as described in Example 1.

Clone No	Strain	LC50 (µl broth/g insect diet)
1	NCIMB 40887	13.03
2	NCIMB 40887	16.7
3	ATTC 19061	108.7
Control*		No effect at 100µl/g

*XL1 Blue *E. coli* broth

When *E. coli* toxin clones were heated at 80°C for 10 minutes and added to the diet at a rate of 100µl/g, no activity to larvae was detected. Highlighting the heat sensitivity of the toxins.

Example 9

Sequencing of the cloned toxin from NCIMB 40887

Cosmid DNA of the entomocidal clone 1 above from NCIMB 40887 was purified using the Wizard Plus SV DNA system (Promega) in accordance with the manufacturers instructions. A partial map of the cloned fragment was obtained using a range of restriction enzymes *Eco*R1, *Bam*H1, *Hind*III, *Sal*1 and *Sac*1 as shown in Figure 3. DNA sequencing was intiatiated from pUC18 and pUC19 based sub-clones of the cosmid, using the enzymes *Eco*R1, *Bam*H1, *Hind*III, *Eco*RV and *Pvu*II. Sequence gaps were filled using a primer walking approach on purified cosmid DNA. Sequence reactions were performed using the ABI PRISM™ Dye Terminator Cycle Sequencing Ready Reaction Kit with AmmpliTaq DNA polymerase FS according to the manufacturers instructions. The samples were analysed on an ABI automated sequencer according to the manufacturers instructions. The major part of the DNA sequence for the cloned toxin fragment is shown in Figure 2.

Example 10

Restriction map of cloned toxin from clone 3

Cosmid DNA of the entomocidal clone 3 above was purified as described in Example 9. A restriction map of the cloned fragment was obtained using the restriction enzymes *Bam*H1, *Hind*III, *Sal*1 and *Sac*1 and this is shown in Figure 3. When compared with the map from clone 1 (Figure 3) it is clear that over the regions which overlap, the restriction maps are very similar. The only detectable difference between the two clones was a reduction in size of two *Hind*III fragments in clone 3, corresponding to the 11.4kb and 7.2kb *Hind*III fragments in clone 1 by approximately 2Kb and 200bp respectively. These results indicate the overall relatedness of the DNA region coding for toxicity in the two bacterial strains.

Example 11

Southern Blot Hybridisation Experiments

A 10.3kb *Bam*H1-*Sal*1 fragment of the DNA from clone 1 was used as a probe to hybidise to total *Hind*III digested DNA of the *Xenorhabdus* strains ATCC 19061, NCIMB 40886 and NCIMB 40887. Hybridisation was performed with 20ng/ml of DIG labelled DNA probe at 65°C for 18 hours. Filters were washed prior to immunological detection twice for 5 minutes with 2 x SSC (0.3M NaCl, 30mM sodium citrate, pH 7.0)/0.1% (w/v) sodium dodecyl sulphate at room temperature, and twice for 15 minutes with 0.1 x SSC (15mM NaClm 1.5 mM sodium citrate, pH 7.0) plus 0.1% sodium dodecyl sulphate at 65°C. The probe was labelled and experiments performed in accordance with manufacturers instructions, using a non-radioactive DIG DNA labelling and detection kit (Boehringer). The probe hybridised to a *Hind*III fragment of approximately 8kb in all three strains as well as an 11.4kb fragment in NCIMB 40887 and an approximate 9kb fragment in both NCIMB 40886 and ATCC 19061. These results show that strains NCIMB

40886 and ATCC 19061 contain DNA with close homology to the toxin gene of clone 1 above, confirming the similarity between the toxins produced by the three strains.

5

CLAIMS

1. An insecticidal composition adapted for oral administration to an insect comprising a pesticidal material obtainable from a *Xenorhabdus* species, or a pesticidal fragment thereof, or a pesticidal variant or derivative of either of these.

2. A composition according to claim 1 wherein the said pesticidal material comprises material encoded by the nucleotide sequence of Figure 2 or variant or fragment thereof, or a sequence which hybridises with said sequence.

3. A composition according to claim 1 or claim 2 which comprises cells of *Xenorhabdus*.

4. A composition as claimed in any one of the preceding claims which comprises supernatant taken from cultures of cells of *Xenorhabdus* species.

5. A composition according to any one of the preceding claims wherein the *Xenorhabdus* species is *Xenorhabdus nematophilus*.

6. A composition according to any one of claims 1 to 4 wherein the *Xenorhabdus* species is ATCC 19061, NCIMB 40886 or NCIMB 40887.

7. A composition as claimed in any one of the preceding claims which comprises a further pesticidal material not obtainable from *Xenorhabdus*.

8. A composition according to claim 7 wherein the said further pesticidal material comprises a material obtainable from *B. thuringiensis*.

9. A composition according to claim 8 which further comprises cells of *B. thuringiensis*.

10. A composition according to claim 8 wherein the pesticidal materials obtainable from *B.thuringiensis* comprises the delta endotoxin.

11. A composition according to any one of the preceding claims which further comprises an agriculturally acceptable carrier.

12. A composition according to claim 10 wherein the carrier comprises items of insect diet.

13. A method for killing or controlling insect pests, which method comprises administering to a pest or the environment thereof a composition according to any one of the preceding claims.

14. A method as claimed in claim 12 wherein the pests are insects from the order Lepidoptera or Diptera.

15. A microorganism comprising *Xenorhabdus* strain NCIMB 40886.

16. A microorganism comprising *Xenorhabdus* strain NCIMB 40887.

17. A pesticidal agent which comprises a a toxin comprising a protein which is encoded by DNA which includes SEQ ID No. 1 or a variant or fragment thereof.

18. An isolated pesticidal agent characterised in that it is obtainable from cultures of *X. nematophilus* or mutants thereof, has oral pesticidal activity against *Pieris brassicae*, *Pieris rapae* and *Plutella xylostella*, is substantially heat stabl to 55°C, is proteinaceous, acts synergistically with *B. thuringiensis* cells as an

oral pesticide, and is substantially resistant to proteolysis by trypsin and proteinase K.

19. An isolated pesticidal agent as claimed in claim 18 further characterised in that the pesticidal activity is substantially destroyed by treatment with sodium dodecyl sulphate or acetone or heating to 80°C.

20. An isolated pesticidal agent as claimed in claim 18 or claim 19 further characterised in that the agent is an extracellular protein.

21. A recombinant DNA which encodes a pesticidal agent according to any one of claims 17 to 20.

22. A recombinant DNA of claim 21 which comprises the sequence of Figure 2 or a variant or fragment thereof.

23. A recombinant DNA which comprises or hybridises under stringent conditions with all or part of the sequence of Figure 2, and which encodes a pesticidal material.

24. An expression vector comprising a recombinant DNA according to any one of claims 21 to 23.

25. A host organism which has been transformed with an expression vector according to claim 24.

26. A host organism as claimed in claim 25 which has been engineered or selected such that it also expresses other pesticidal proteinaceous toxicity enhancing materials

27. A host organism comprising a nucleotide sequence coding for a fusion protein comprising a pesticidally active portion of an agent as claimed in any one of claims 17 to 20 in combination with other pesticidal proteinaceous toxicity enhancing materials.

28. A host organism as claimed in claim 27 wherein the pesticidal toxicity enhancing materials comprise delta-endotoxin from B. thuringiensis.

29. A host organism as claimed in any one of claims 25 to 289 wherein the host is a plant.

30. A host organism as claimed in any one of claims 25 to 28 wherein the host is a virus pathogenic to insects.

31. A fusion protein as expressed by a host as claimed in claim 27.

32. An pesticidal composition comprising one or more agents as claimed in any one of claims 17 to 20.

Fig.1.

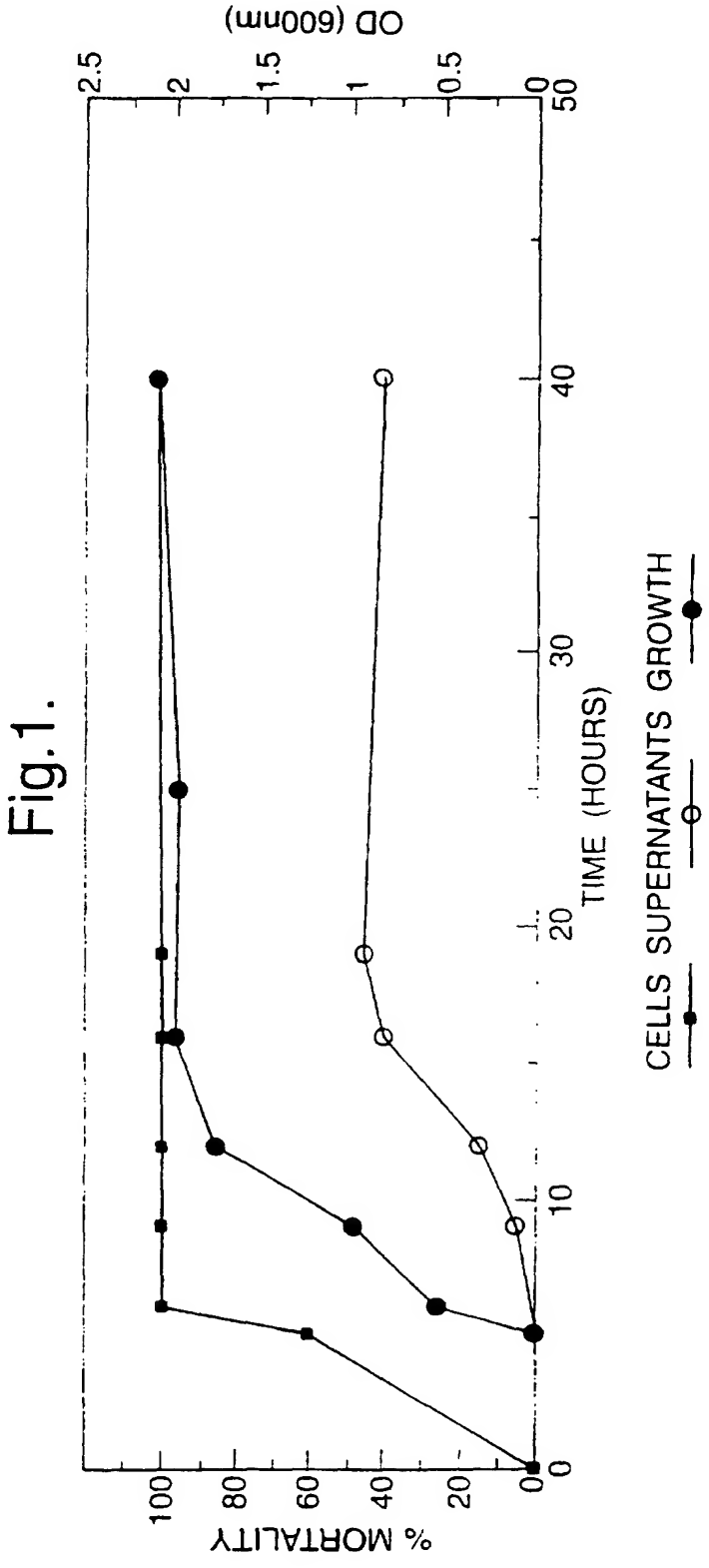

Fig.2.

```
   1 TCCACAATTG CCGGAGAAAA TCAGTCGGGA ACTGCCGGTG ATTATTCGTC ACTTATTAAA
  61 CGAATTTGCC GACCAGAATA AGGCTAAAAA ACTGCTACAG GCGCAACGCG ACTCGAACGA
 121 AGCGTTAACG GTAAAGAGTC ATTCGGATCC GCTGTATCGC TTTTGTGGTT ATCTGGTGTC
 181 TGTCAATGAT ATGACCGGAA TGAAGATGGG CAATAAAAAC ATTAGCCCAC GAGCACCGAG
 241 ATTGTACTTG TATCATGCCT ATCTCTCTTT TATGGAAGCG CACGGCTTTG AACGTCCGTT
 301 AACACTGACT AAGTTTGGTG AATCCATCCC CAAGATTATG CTGGAATACC GGAAGGAGTA
 361 TCGAAAAGTG CGAACCAAGA AAGGCTATTC CTATAACGTG GAATTATCGG AAGAGGCCGA
 421 AGAATGGCTA CCGTCAGTGC CTGAGTGTCG AGACTTTAAA TCACCTGTAT AAAACTTTGA
 481 GCTTTAAGTC TGCACTCCAT ACACAACTTA AAATATCTAA TTGTATTTAA AAGAAAATAA
 541 TAGATGTATA GTTATTTTTT AACTATACAT AAGCTCTACA TGCTCTTCAT TCGTGTAAAA
 601 AATGGGTGAA CAGGTGATAC AGTCAGTGAA TATCATATTA ATTACCGTAA ACCCAGATGT
 661 AGCAAGGCTT TCAGGGAATT GTGCAGAGGG TGCATAACTG AGAGGGTGAA AAAGATTTTC
 721 AGGGGGGCTT ATGGCAGGTA AACAAAATCA GAAGCAAATA CCGTGCACAA TCTGGTTTTT
 781 ATTTTTTGGT ACTACCTCAA ATTAAAATGA TGTAATCATC TGATTTTATT TAAGAATAGA
 841 AGTTAATCAC AATTTCATTG ATGGACTTTC ATTCACACTG GTATAGATAA ATAATTCTGT
 901 TATATCCTGT TTCATTACGC ATTCATCAGG AGTGCTGTTA CAGGAGACAA GAATGTCACA
 961 CATCATTTAC TTGTCGTTAA AGGGCAAGAA GCAGGGTTTA ATTTCAGCGG GTTGTTCAAC
1021 GCCTGAATCA ATTGGAAATC GCTATCAAAA AGGACGTGAA GATCAAATAC AGGTATTGAG
1081 CCTGAATCAT TCGATGAGCC GTGACCAGAA TGTTAATCAT CAACCCGTCA GTTTTGTGAA
1141 ACCCATTGAT AAATCCTCTC CCCTGTTTGC TGGATGCCAG TTTTGTGCAT TACAGGACAA
1201 GCCAGATGGG ACAACTGGAG TTCTTTTATG AAATCAAGCT GACCAGTGCC ACGATTGTGG
1261 ATATTTCCTA TAATTATCCG GCATTCAATC AATGATAATG GTGCGATACC CCATGAAGTG
1321 GTGATGCTCG ATTATAAGTC CATTTCATGC AACCACATCG CCGCAGGACT TCGGGCTACA
1381 GCATACGCAA TTAGCCGGAA GTGAAGAAGC AAGCCGCTTT TATCTGGGGT CTCGAATGTT
1441 AAGCCACTTA AGAAGCCGCT GGTTGAAGAA ACCCCGGTAA AACCCGCTAA ACATCATGCC
1501 CGTTATCGTT GTGTGGATGA TGACGGCAAT CTTTTAACCG AACGCAAGTA TCGGGTTTGC
1561 CTGCCGGATG GTCAGATAAA AGAAGGAAAG ACTGATAAAC AAGGTTACAC CCAATGGCAT
1621 CTTACGGATG ACAAAAATAA ACTTGAATTT CATATTTTAA AGGATTAATA CCATGCCAGC
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1741 AACCATTTAT CGTAAGGATG CAAAAGGAAA TTTCCATATC TTGCTTGATG TTTTTCAGGA
1801 GAAACTACAG AGTAATTATG AAACACAACA GCATATCACG CAGGAAATAG ACGACGATCT
1861 TTCTGTGATT TATATTATGC AAATTATGCT TCACCGCAAA CATGGCTCAA ATATATTTCC
1921 GGCACTGCAA ACCCATTTTA AGAAAATGTA TACCCTCGGT GAATTAACTT CCGGTAAAGC
1981 CTGTTCGGAG AAAAAACGGG AAAATGCCTG TTATTTTGAA AGTACAGTTG AAACAAAACC
2041 TGTCAGCGAC GGGGATAATA CCGTTGACTT AAATATCACT ATTCCTGAAC GACCTTTTAT
2101 TGCCAAAGAA TATCCCATTG GTCACCCACA CGATCCATTT GAAAAAAGTA AAATTGAATC
2161 ATAAATACAG GACAGGTTAT CGAAAAGAAT TTATCCGGAT CAAAATGGAG CAAGTTTATG
2221 TCAGGGCGCG AGCACACTAT TTTAGCTGCG TTTTTAAGAT GATTATCTCT TAATGTTCAG
2281 TTTTAATAGT GTTTTTATCG AGTGAAATTT AATCGCACAG GCAATTCTTT AGACTTTTAT
2341 AGAAAACTAA AGAATTAAAG AACAAGATTG ACATTTTAAG TTCAAATATT AATCAAAGTA
2401 TGCTCGCGCC CTGAGTTTAT GTGGCCCTGC CGCTTTTTTT TATTGCCTGC CAATAGATAG
2461 ACCAGATATT TATGAGCAAG CGGCACGAGA ATTATGGCAA TATGGCCGAA CTAAAATTGG
2521 TCAACTGGAA ATTAAGCCGG GTGAGGGTTG CCGACATCCT AAAGGTACTT TTTATAATCA
2581 ATATGGTGAA AGAATATCTG GGTTAGATTG GCTGACATTG GCAAGCCTAA GAGATTCAGA
2641 AAATATGATG ATGAGGTTGA TGATGAAGTA GCTGGTATTA CAATGTGGGG AAAATTGACA
2701 GAATGGTTTG AAAAATCAGG GTATGAAAAA GTATTTAGTA ATGTCGGCTT ATCCCATTCT
2761 AATATAAATG ACATAGTAAC TCTTAGTGAT TACTATAACA AAGGATATCA TGTTGTTACT
2821 TTGATTTCAG CAGGAATGTT ATCAGATTTT GGTGACATAG AAACATCAGG AAAAAATCAT
2881 TGGATAGTTT GGGAAGGAGT AGTAGAAAAC TATGAGAAAG AAAATATCAC AAATAATTCA
2941 GATCTGAATC AATATGTAAA TTTAAATCTG TTTTCATGGG GTAAAGTGGA ACATCAAATT
3001 AAAAAAAACA AATCACTAGA TTATGTACTC AACCATATTT TTTGAGGGTT GGTTTTTAAA
3061 CCAATGAAAT AACATGAAAA AAATATTAAT TATTTTTATT TTTTTACTTT ATGGTTGTGG
3121 TAATCCAACG CCAAAAGTTT TACCAAAATC AGAGTTTCTT CCTGATGCAG TGATAAATGA
3181 ACCATATCAG GCATCAATTA CCATCACAGG AGGTGCATTG AATGAAAAAA GCGTTTGGGT
3241 AAAAATTCAT CCTACTGGCT CAGGACTAAC ATGGAATCCA AAAGATAGTT CTTTCCTATA
3301 GGGTGGAAAA AAAGAAATAA GAAAAGATTA TCATCATATA AATATAACAG GTACCCCAAA
3361 GAAGACAGAA TTGATAAAAA TTGAAGTGGT AGGATTTACA TTGGGTACAA TGTACGCACG
3421 GAAAGAGTTC ACTATAAATT ATACTATAAA AGTAAGGGAA TAATTGTCAC TATCAGAATG
3481 GTGATTTAAT TCGCCATTTT TATACTTTTG TATACTCTCT CAACATAATC AGGATTCTTT
```

Fig.2.

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3541  CTTATTATTT TTCATGGTGC TAAAAACGTT TATTGCAAAA ATAAATTAAG TTAATCAGAT
3601  AAATTATCTG CATTACTGTT ATAATCGATA ACACGATAAC CTGACTTTCT GCCTGTTCTT
3661  ATGAACTCGA AGATAATCCT TTCTGAGCCT GAACGAATCA CATTGCAACC ACTCGCTTTG
3721  AATCACCCAC ACCGGGACAT TCGTACGCGA GGAACGGGTT TACTCATGCT TGCCAGAGGG
3781  AGCAAGCCGT CCCAGATCAC CGCTGAAATC GGATGCAGTC TCCGGGTTAT CTGTAATTGG
3841  GTTCACATGT GGCACAGATA GCGGGATTAT TCGGCGGTCA TGCCGGAGGC CGGTATCTCG
3901  CCATGACGCC TGACATGATT GCCACTGCGC TCGAAGCCGC CAGCGCAGAG TCCCTGACGT
3961  GCGTCGAAGC CAGGCAGGGT TTCCCTGCCT TGTACGCTTG AAACGCTGGC GAATACCCTG
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4081  CGGAGTTTGC TGAAAAATCC GCCTTGCTGA ATAAAATTAA GGCCGGAGCA CAGTCAGGAC
4141  ATTACCGTCT GGTCTATTTT GAGTTCTGGG GGCGTTAAAT TACACGGATA ACACGCTGTT
4201  TTACCAGACA ACGTCAGGCA GTATCACGCG AGATGACGTG ATTGATTTTT TAGAGCCGGT
4261  GGCCAGACAA GGGACAACCG CCTGACATTT TTAGTGTTGG ATAATGCGCG TATCCATCAC
4321  GGGATAGAGG AAAAAATCAG AAATGGCGGG TGACGAGAAC ACAACCTGTT TTTATTCTAT
4381  CTTCCCGCTT ACAGCCCAGA GCTGTATCTG ATTGAAATCG TCTGGAAACA GGCCAAATAC
4441  GACTGGCGAC GTTTTATCAC CTGGACTCAG GATACAATGG AATATGAGGT AAATACTTTA
4501  TTGAAAGGTT ATGGCGACCA ATTTGCAATT AACTTTTCTT GAGTACTTAG TAAGAATAGA
4561  GTCAGTCGAG GTTTTTTCAT TTCGGGTCGT GGGGATGATA CTGAAAATTT GTTTGTAATC
4621  TCTGAAAATT GCTGTTTCTG TGGCTACGTC TGTCTTTTGG GATATTGTTT CCATCAAGTC
4681  TGTCAACATA CTGTTAAGTT AGATGTTGAT AAAAGAGACT GAATTATAAT ACAAAACAAT
4741  AAATCACTTG GACAATATTT TATTTCACAT GAGACATTAA GGTTGATTTT CCCAATCTGG
4801  TCAGTTATAA CCGAATAAGG ATCTTGAAAA ATCATGGGAT CTTACTTTTA TCAAATGAAG
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4921  TGTGTTTTGT TAATGAATGA ATAACCAGGT AAGCTGGATT TTCATTTTTT AATTACTCGT
4981  TACAATATGC TATTTATTTA TATAAAGAGT TTGTGCCCAT TTAACCAGTA AACAAATTTG
5041  TTCAACCGTA ACTTAGCTTC ATCGACTTTT GGCCTCGCCT GGTCAGAATC TAGGGCCGTT
5101  ATCCTATTTA TTTATGATAA ATAAAATTTA ATTATCTTTA ATAAGCTGAA TATGTGGATT
5161  TGTGCTCAAT CTTGGATTCA AGTATGTATT CCTTTTGGTA CCCTGCTTTA TTTTAAGGCA
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5281  TAAATTTTAT GATTAAAATG AAATTTTAGT AGAAAATCGT ATTCTATTCC GCCATTTACA
5341  ATAGCATCCT CTTTAATATC ATTAATCTCA GATAAAACAA ATAATTACAA TGTGAATAGA
5401  ATAATGACTT ACAAAATAAG CACTAAATCT TCAGATGAAC TCTTAACTGA CAACACTATT
5461  TTATAAAATA ATTGAGGTTA TTATGTATAG CACGGCTGTA TTACTCAATA AAATCAGTCC
5521  CACTCGCGAC GGTCAGACGA TGACTCTTGC GGATCTGCAA TATTTATCCT TCAGTGAACT
5581  GAGAAAAATC TTTGATGACC AGCTCAGTTG GGGAGAGGCT CGCCATCTCT ATCATGAAAC
5641  TATAGAGCAG AAAAAAAATA ATCGCTTGCT GGAAGCGCGT ATTTTTACCC GTGCCAACCC
5701  ACAATTATCC GGTGCTATCC GACTCGGTAT TGAACGAGAC AGCGTTTCAC GCAGTTATGA
5761  TGAAATGTTT GGTGCCCGTT CTTCTTCCTT TGTGAAACCG GGTTCAGTGG CTTCCATGTT
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5881  CTCTGCTTAT CATCTTGATA ATCGCCGTCC GGATCTGGCT GATCTGACTC TGAGCCAGAG
5941  TAATATGGAT ACAGAAATTT CCACCCTGAC ACTGTCTAAC GAACTGTTGC TGGAGCTATT
6001  ACCCGCAAGA CCGGAGGTGA TTCGGACGCA TTGATGGAGA GCCTGTCAAC TTACCGTCAG
6061  GCCATTGATA CCCCTTACCA TCAGCCTTAC GAGACTATCC GTCAGGTCAT TATGACCCAT
6121  GACAGTACAC TGTCAGCGCT GTCCCGTAAT CCTGAGGTGA TGGGGCAGGC GGAAGGGGCT
6181  TCATTACTGG CGATTCTGGC CAATATTTCT CCAGAACTGT ATAACATTTT GACCGAAGAG
6241  ATTACGGAAA AGAACGCTGA TGCTTTATTT GCGCAAAACT TCAGTGAAAA TATCACGCCC
6301  GAAAATTTCG CGTCACAATC ATGGATAGCC AAGTATTATG GTCTTGAACT TTCTGAGGTG
6361  CAAAAATACC TCGGGATGTT GCAGAATGGC TATTCTGACA GCACCTCTGC TTATGTGGAT
6421  AATATCTCAA CGGGTTTAGT GGTCAATAAT GAAAGTAAAC TCGAAGCTTA CAAAATAACA
6481  CGTGTAAAAA CAGATGATTA TGATAAACAT GTAAATTACT TTGATCTGAT GTATGAAGGA
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6601  AGGAAAAACT CAGGGACAAG TGGCATTGTC GGCAGCCTTT CCGGTCCCCT GGTAGCCAAT
6661  ACTAATTTCA AAAGCAATTA CTTAAGTAAC ATATCTGATA ATGAATACAG AAATGGCGTA
6721  AAAATATATG CCTATCGCTA TACGTCTTCC ACCAGCGCCA CAAATCAGGG CGGCGGAATA
6781  TTCACTTTTG AGTCTTATCC CCTGACTATA TTTGCGCTCA AACTGAATAA AGCCATTCGC
6841  TTGTGCCTGA CTAGCGGGCT TTCACCGAAT GAACTGCAAA CTATCGTACG CAGTGACAAT
6901  GCACAAGGCA TCATCAACGA CTCCGTTCTG ACCAAAGTTT TCTATACTCT GTTCTACAGT
6961  CACCGTTATG CACTGAGCTT TGATGATGCA CAGGTACTGA ACGGATCGGT CATTAATCAA
7021  TATGCCCGAC GATGACAGTG TCAGTCATTT TAACCGTCTC TTTAATACCC CGCCGCTGAA
7081  AGGGAAAATC TTTGAAGCCG ACGGCAACAC GGTCAGCATT GATCCGGATG AAGAACAATC
7141  TACCTTTGCC CGTTCAGCCC TGATGCGTGG TCTGGGGATC AACAGTGGTG AACTGTATCA
7201  GTTAGGCAAA CTGGCGGGTG TATTGGACAC ACAAAATATC CTCACACTTT CTGTCCCTGT
7261  TATATCTTCA CTGTATCGCC TCACGTTACT GGCCCGTGCC CATCAGCTGA CGGTTAATGA
7321  ACTGTGTATG CTTTATGGTT TTTCGCCGTT CAATGGCAAA ACAACGGCTT CTTTGTCTTC
```

Fig.2.

```
 7381  CGGGGAGTTG TCACGGCTGG TTATCTGGTT GTATCAGGTG ACGCAGTGGC TGACTGAGGG
 7441  CGGAAATCAC CACTGAAGCG ATCTGGTTAT TATGTACGCC AGAGTTCAGC GGGAATATTT
 7501  CACCGGAAAT CAGTAATCTG CTTAATACTC TCCGACCCCG TATTAGTGAA GACATGGCAC
 7561  AAAGTAGTGA CCGGGAGCTT CAGGCTGAAA TTCTCGCGCC GTTTATTGCT GCAACGCTGC
 7621  ATCTGGCGTC ACCAGATATG GCGCGGTATA TCCTGTTGTG GACTGATAAC CTGCGGCCGG
 7681  GCGGCCTGAA TATCGCCGGA TTTATGATGC TGGTGCTGAA AGAGACGCTG AGTGATGAGG
 7741  AAACGACCCA ACTGGTTCAA TTCTGCCATG TAATGGCACA GTTATCGCTT TCCGTGCAGA
 7801  CACTGCGTCT CAGTGAAGCA GAGCTTTCTG TGCTGGTCAT TTCCGATTTT GTGGTACTGG
 7861  GTGCGAGAAG CCAACCGCCG GACAACACAA TATTGATACT CTGTTCTCAC TCTACCGATT
 7921  CCACCAGTGG ATTAATGGGC TGGGAAATCC CGGCTCTGAC ACGCTGGATA TGCTGCGCCA
 7981  AGCAGACACT CACGGGCGAC AGACTGGGCC TCCGTGATGG GGCTGGACAT CAGTATGGTA
 8041  ACGCAGGCCA TGGGTTCCCG CCGGCGTGAA CCAACTTCAG TGTTGGCAGG ATATCAACCC
 8101  CGTGTTGCAG TGGATACATG TGGCATCAGC ACTGCTCACT GATGCCGTCG GTTATCCGTA
 8161  CGCTGGTGAA TATCCGTTAC GTGACTGCAT TAAACAAAGC CGAGTCGAAT CTGCCTGCCT
 8221  GGGATAAGTG GCAGACGCTG GCAGAAAATA TGGCAGCCGG ACTGAGTACA CAACAGGCTC
 8281  AGACGCTGGC GGATTATACC GCAGAGCGCC TGAGTAACGT GTTGTGCAAT TGGTTTCTGG
 8341  CGAATATCCA GCCAGAAGGG GTGTCCCTGC ACAGCCGGGA TGACCTGTAC AGCTATTTCC
 8401  TGATTGATAA TCAGGTCTCT TCTGCCATAA AAACCACCCG ACTGGCAGAG GCCATTGCCG
 8461  GTATTCAGCT CTACATCAAC CGGGCGCTGA ACCGGATAGA GCCTAATGCC CGTGCCGATG
 8521  TGTCAACCCG CCAGTTTTTT ACCGACTGGA CGGTGAATAA CCGTTACAGC ACCTGGGGCG
 8581  GGGTGTCGCG GCTGGTTTAT TATCCGGAAA ATTACATTGA CCCGACCCAG CGTATCGGGC
 8641  AGACCCGGAT GATGGATGAA CTGCTGGAAG ATATCAGCCA GAGTCAGCTC AGCCGGGACA
 8701  CGGTGGAAGA GGCCTTTAAA ACTTACCTGA CCGCTTTGAA ACCGTGGCAG ACCTGAAAGT
 8761  TGTCAGCGCT ATCACCGACA ACGTCAACAG CAACACCGGA CTGACCTGGT TTGTCGGCCA
 8821  AACGCGGGAG AACCTGCCGG AATATTACTG GCGTAACGTG CATATATCAC GGATGCAGGC
 8881  GGGTGAACTG GCCGCCGATG CCTGGAAAGA TTGGACGAAG ATTGATACAG CGGTCAACCC
 8941  ATACAAGGAT GCAATACGTC CGGTCATATT CAGGGAACGT TTGCACCTTA TCGTGGGTAG
 9001  AAAAAGAGGA AGTGGCGAAA AATGGTACTG ATCCGGTGGA AACCTATGAC CGTTTTACTC
 9061  TGAAACTGGC GTTTCTGCGT CATGATGGCA GTTGGAGTGC CCCCTGGTCT TACGATATCA
 9121  CAACGCAGGT GGAGGCGGTC ACTGACAAAA AACCTGACAC TGAACGGCTG GCGCTGGCCG
 9181  CATCAGGCTT TCAGGGCGAG GATACTCTGC TGGTGTTTGT GTACAAAACC GGGGTGAGTT
 9241  ACCCGGATTT TGGCGACAAC AATAAAAATG TGGCAGGCAT GACCATTTAC GGCGATGGCT
 9301  CCTTCAAAAA GATGGAGAAC ACAGCACTCA GCGTTACAGC CAACTGAAAA ATACCTTTGA
 9361  TATCATTCAT ACTCAAGGCA ACGACTTGGT AAGAAAGGCC AGCTATCGTT TCGCGCAGGA
 9421  TTTTGAAGTG CCTGCCTCGT TGAATATGGG TTCTGCCATC GGTGATGATA GTCTGACGGT
 9481  GATGGAAAAC GGGAATATTC CGCAGATAAC CAGTAAATAC TCCAGCGATA ACCTTGCTAT
 9541  TACGCTACAT AACGCCGCTT TCACTGTCAG ATATGATGGC AGTGGCAATG TCATCAGAAA
 9601  CAAACAAATC AGCGCCATGA AACTGACGGG GTTGGATGAA AGTCCCAGTA CGGCAATGCA
 9661  TTTATCATCG CAAATACCGT TAAACATTAT GGCGGTTACT CTGATCTGGG GGGCCCGATC
 9721  ACCGTTTTTA TTAAAACGGA AAAACTATAT TGCATCAGTT CAAGGCCACT TGATGAACGC
 9781  AGATTACACT AGGCGTTTGA TTCTAACACC AGTTGAAAAT AATTATTATG CCAGATTGTT
 9841  CGAGTTTCCA TTTTCTCCAA ACACAATTTT AAACACCGTT TTCACGGTTG GTAGCAATAA
 9901  AACCAGTGAT TTTAAAAAGT GCAGTTATGC TGTTGATGGT AATAATTCTC AGGGCTTCCA
 9961  GATATTTAGT TCCTATCAAT CATCCGGCTG GCTGGATATT GACACAGGTA TTAACAATAC
10021  TGATGTCAAA ATTACGGTGG TAGCTGGCAG TAAAACCCAC ACCTTTACGG CCAGTGACCA
10081  TATTGCTTCC TTGCCGGCAA ACAGTTTTGA TGCTATGCCG TACACCTTTA AGCCACTGGA
10141  AATCGATGCT TCATCGTTGG CCTTTACCAA TAATATTGCT CCTCTGGATA TCGTTTTTGA
10201  GACCAAAGCC AAAGACGGGC GAGTGCTGGG TAAGATCAAG CAAACATTAT CGGTGAAACG
10261  GGTAAATTAT AATCCGGAAG ATATTCTGTT TCTGCGTGAA ACTCATTCGG GTGCCCAATA
10321  TATGCAGCTC GGGGTGTATC GTATTCGTCT TAATACCCTG CTGGCTTCTC AACTGGTATC
10381  CAGAGCAAAC ACGGGCATTG ATACTATCCT GACAATGGAA ACCCAGCGGT TACCGGAACC
10441  TCCGTTGGGA GAAGGCTTCT TTGCCAACTT TGTTCTGCCT AAATATGACC CTGCTGAACA
10501  TGGCGATGAG CGGTGGTTTA AAATCCATAT CGGGAATGTT GGCGGTAACA CGGGAAGGCA
10561  GCCTTATTAC AGCGGAATGT TATCCGATAC GTCGGAAACC AGTATGACAC TGTTTGTCCC
10621  TTATGCCGAA GGGTATTACA TGCATGAAGG TGTCAGATTG GGGGTTGGAT ACCAGAAAAT
10681  TACCTATGAC AACACTTGGG AATCTGCTTT CTTTTATTTT GATGAGACAA AACAGCAATT
10741  TGTATTAATT AACGATGCTG ATCATGATTC AGGAATGACG CAACAGGGGA TCGTGAAAAA
10801  TATCAAGAAA TACAAAGGAT TTTTGAATGT TTCTATCGCA ACGGGCTATT CCGCCCCGAT
10861  GGATTTCAAT AGTGCCAGCG CCCTCTATTA CTGGGAATGT TCTATTACAC CCCGATGATG
10921  TGCTTCCAGC GTTTGCTACA GGAAAAACAA TTCGACGAAG CCACACAATG GATAAACTAC
10981  GTCTATAATC CCGCCGGCTA TATCGTTAAC GGAGAAATCG CCCCCTGGAT CTGGAACTGC
11041  CGGCCGCTGG AAGAGACACT CCTGGAATGC CAATCCGTTG GATGCCATTG ATCCGGATGC
11101  CGTCGCACAA TATGACCCGA CACACTATAA AGTTGCCACC TTTATGCGCC TGTTGGATCA
11161  ACTTATTCTG CGCGGCGATA TGGCCTATCG CGAACTGACC CGCGATGCGT TGAATGAAGC
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Fig.2.

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11221  CAAGATGTGG TATGTGCGTG CTTTGGAATT GCTGGGTGAT GAGCCGGAGG ATTACGGCAG
11281  CCAACAGTGG GCCGCACCGT CTCTTTCCGT GGCGGGCAAC CACACTGTGC AAGCGGGCTA
11341  TCAACAAGAC CTTACGGCGC TAGACAACGG AGAAGGTTGC ACTCAACCCC GCAACGCTAA
11401  CTCGTTGGTG GTTTGGTCCT GCCGGAATAT AACCCGGAAT CAACCGATTA CTGGCAAACC
11461  TGCGTTTGCG CCTGGTTAAC CTGCGCCATA ATCCTTCCAT GACGGGCAAC CGTTATCGCT
11521  GGCGAATTAC GCGAGCCTAC GATCCGAAAG CGCTGCTCAC CAGTATGGTA CAGCCTTCTC
11581  AGGGCGGTAG TGCAGTGCTG CCCGGCACAT TGTCGTTATA CCGCTTCCCG GTGATGCTGG
11641  AGCGGGCCCG CAATCTGGTA GCGCAATTAA CCCAGTTCGG CACCTCTCTG CTCAGTATGG
11701  CAGAGCATGA TGATGCCGAT GAACTCACCA CGTTGCTACT ACAGCAGGGT ATGGAACTGG
11761  CGACACAGAG CATCCGTATT CAGCAACGAA CTGTCGATGA AGTGGATGCT GATATTGCTG
11821  TATTGGCAGA GAGCCGCCGC AGTGCACAAA ATCGTCTGGA AAAATACCAG CAGCTGTATG
11881  ACGAGGATAT CAACCACGGA GAACAGCGTG CGATGTCACT GTTTGATGCG GCGGCAGGTC
11941  AGTCTCTGGC CGGGCAGGCG CTCTCAGTAG CAGAAGGGGT GGCTGACTTA GTTCCAAACG
12001  TGTTCGGTTT CGCTTGTGGC GGCAGTCGTT GGGGGGCAGC ACTGCGTGCT TCCGCCTCCG
12061  TGATGTCGCT TTCTGCCACA GCTTCCCAAT ATTCCGCAGA CAAAATCAGC CGTTCGGAAG
12121  CCTACCGCCG CCGCCGTCAG GAGTGGGAAA TTCAGCGTGA TAATGCTGAC GGTGAAGTCA
12181  AACAAATGGA TGCCCAGCTG GAAAGCCTGA AAATACGCGG CGAAGCAGCA CAGATGCAGG
12241  TGGAATATCA GGAGACCCAG CAGGCCCATA CTCAGGCTCA GTTAGAGCTG TTACAGCGTA
12301  AATTCACAAA CAAAGCGCTT TACAGTTGGA TGCGCGGCAA GCTGAGTGCT ATCTATTACC
12361  AGTTCTTTGA CCTGACCCAG TCCTTCTGCC TGATGGCACA GGAAGCGCTG CGCCGCGAGC
12421  TGACCGACAA CGGTGTTACC TTTATCCGGG GTGGGGCCTG GAACGGTACG ACTGCGGGTT
12481  TGATGGCGGG TGAAACGTTG CTGCTGAATC TGGCAGAAAT GGAAAAAGTC TGGCTGGAGC
12541  GTGATGAGCG GGCACTGGAA GTGACCCGTA CCGTCTCGTT GGCACAGTTC TATCAGGCCT
12601  TATCATCAGA CAACTTTAAT CTGACCGAAA AACTCACGCA ATTCCTGCGT GAAGGGAAAG
12661  GCAACGTAGG AGCTTCCGGC AATGAATTAA AACTCAGTAA CCGCCAGATA GAAGCCTCAG
12721  TGCGATTGTC TGATTTGAAA ATTTTCAGCG ATACCCCGGA AAGCTTTGGC AATACCCGTC
12781  AGTTGAAACA AGTGAGTGTC ACCTTGCCGG CGCTGGTTGG TCCGTATGAA GATATCCGGG
12841  CGGTGCTGAA TTACGGCGGC AGCATCGTCA TGCCACGCGG TTGCAGTGCT ATTGCTCTCT
12901  CCCACGGCGT GAATGACAGT GGTCAATTTA TGCTGGATTT CAACGATTCC CGTTATCTGC
12961  CGTTTGAAGG TATTTCCGTG AATGACAGCG GTAGCCTGAC GTTGAGTTTC CCGGATGCGA
13021  CTGATCGACA GAAAGCGCTG CTGGAGAGCC TGAGCGATAT CATTCTGCAT ATCCGCTATA
13081  CCATTCGTTC TTAATTAAAA CATTGTGATA GGCAGGCTCC TGAGGGAGCC TGTTTAAGGA
13141  GTTTTTATGC AGGGTTCAAC ACCTTTGAAA CTTGAAATAC CGTCATTGCC CTCTGGGGGC
13201  GGATCACTAA AAGGAATGGG AGAAGCACTC AATGCCGTCG GAGCGGAAGG GGAGCGTCAT
13261  TTTCACTGCC CTTGCCGATC TCTGTCCGGC GTGGTCTGGT GCCGGTGCTA TCACTGAATT
13321  ACAGCAGTAC TGCTGGCAAT GGGTCATTCG GGATGGGGTG GCAATGTGGG GTTGGTTTTA
13381  TCAGCCTGCG TACCGCCAAG GGCGTTCCGC ACTATACGGG ACAAGATGAG TATCTCGGGC
13441  CGGATGGGGA AGTGTTGAGT ATTGTGCCGG ACAGCCAAGG GCAACCAGAG CAACGCACCG
13501  CAACCTCACT GTTGGGGACG GTTCTGACAC AGCCGCCTAC TGTTACCCGC TATCAGTCCC
13561  GCGTGGCAGA AAAAATCGTT CGTTTAGAAC ACTGGCAGCC ACAGCAGAGA CGTGAGGAAG
13621  AGACGTCTTT TTGGGTACTT TTTACTGCGG ATGGTTTAGT GCACCTATTC GGTAAGCATC
13681  ATCATGCACG TATTGCTGAC CCGCAGGATG AAACCAGAAT TGCCCGCTGG CTGATGGAGG
13741  AAACCGTCAC GCATACCGGG GAACATATTT ACTATCACTA TCGGGCAGAA GACGATCTTG
13801  ACTGTGATGA GCATGAACTT GCTCAGCATT CAGGTGTTAC GGCCCACCGT TATCCTGGCA
13861  AGTCCACTAT GGCAATACTC AGCCGGAAAC CGCTTTTTTC GCGGTAAAAT CAGGTATCCC
13921  TGTTGATAAT GACTGGTTGT TTCATCTGGT ATTTGATTAC GGTGAGCGCT TATCTTCGCT
13981  GAACTCCGTA CCCGAATTCA ATGTGTCAGA AAACAATGTG TCTGAAAACA ATGTGTCTGA
14041  AAAATGGCGT TGTCGTCCGG ACAGTTTCTC CCGCTATGAA TATGGGTTTG AAATTCGAAC
14101  CCGTCGCTTG TGTCGCCAAG TTCTGATGTT TCATCAGCTG AAAGCGCTGG CAGGGGAAAA
14161  GGTTGCAGAA GAAACACCGG CGCTGGTTTC CCGTCTTATT CTGGATTATG ACCTGAACAA
14221  CAAGGTTTCC TTGCTGCAAA CGGCCCGCAG ACTGGCCCAT GAAACGGACG GTACGCCAGT
14281  GATGATGTCC CCGCTGGAAA TGGATTATCA ACGTGTTAAT CATGGCGTGA ATCTGAACTG
14341  GCAGTCCATG CCGCAGTTAG AAAAAATGAA CACGTTGCAG CCATACCAAT TGGTTGATTT
14401  ATATGGAGAA GGAATTTCCG GCGTTACTTT ATCAGGATAC TCAGAAAGCC TGGTGGTACC
14461  GTGCTCCGGT ACGGGATATC ACTGCCGAAG GAACGAATGC GGTTACCTAT GAGGAGGCGA
14521  AACCACTGCC ACATATTCCG GCACAACAGG AAAGCGCGAT GTTGTTGGAC ATCAATGGTG
14581  ACGGGCGTCT GGATTGGGTG ATTACGGCAT CAGGGTTACG GGGCTACCAC ACCATGTCAC
14641  CGGAAGGTGA ATGGACACCC TTTATTCCAT TATCCGCTGT GCCAATGGAA TATTTCCATC
14701  CGCAGGCAAA ACTGGCTGAT ATTGATGGGG CTGGGCTGCC TGACTTAGCG CTTATCGGGC
14761  CAAATAGTGT ACGTGTCTGG TCAAATAATC CGGCAGGATG GGATCGCGCT CAGGATGTTA
14821  TTCATTTGTC AAATAAGCCA CTGCCGGTTC CCGGCAAAAA TAAGCGTCAT CTTGTCGCAT
14881  TCAGTGATAT GACAGGCTCC GGGCAATCAC ATCTGGTGGA AGTTACGGCA AATAGCGTGC
14941  GCTACTGGCC GAACCTGGGG CATGGAAAAT TTGGTGAGCC TCTGATGATA ACAGGCTTCC
15001  AAATTACGGG GAAACGTTTA ACCCCCACAG ACTGTATATG GTAGACCTAA ATGGCTCAGG
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Fig.2.

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15061 CACCACCCGA TTTTATTTAT GCCCGCAATA CTTACCTTGA ACTCTATGCC AATGAAAGCG
15121 GCAATCATTC TGCTGAACCT CAGCGTATTG ATCTGCCGGA TGGGGTACGT TTTGATGATA
15181 CTTGTCGGTT ACAAATAGCG GATACACAAG GATTAGGGAC TGCCAGCATT ATTTTGACGA
15241 TCCCCCATAT GAAGGTGCAG CACTGGCGAT TGGATATGAC CATATTCAAG CCTTGGCTGC
15301 TGAATGCCGT CAATAACAAT ATGGGAACAG AAACCACGCT GTATTATCGC AGCTCTGCCC
15361 AGTTCTGGCT GGATGAGAAA TTACAGGCTT CTGAATCCGG GATGACGGTG GTCAGCTACT
15421 TACCGTTCCC GGTGCATGTG TTGTGGCGCA CGGAAGTGCT GGATGAAATT TCCGGTAACC
15481 GATTGACCAG CCATTATCAT TACTCACATG GTGCCTGGGA TGGTCTGGAA CGGGAGTTTC
15541 GTGGTTTTGG GCGGGTGACG CAAACTGATA TTGATTCACG GGCGAGTGCG ACACAGGGGA
15601 CACATGCTGA ACCACCGGCA CCTTCGCGCA CGGTTAATTG GTACGGCACT GGCGTACGGG
15661 AAGTCGATAT TCTTCTGCCC ACGGAATATT GGCAGGGGGA TCAACAGGCA TTTCCCCATT
15721 TTACCCCACG CTTTACCCGT TATGACGAAA AATCCGGTGG TGATATGACG GTCACGCCGA
15781 GCGAACAGGA AGAATACTGG TTACATCGAG CCTTAAAAGG ACAACGTTTA CGCAGTGAGC
15841 TGTATGGGGA TGATGATTCT ATACTGGCCG GTACGCCTTA TTCAGTGGAT GAATCCCGCA
15901 CCCAAGTACG TTTGTTACCG GTGATGGTAT CGGACGTGCC TGCGGTACTG GTTTCGGTGG
15961 CCGAATCCCG CCAATACCGA TATGAAGGGG TTGTTACCGA TTCCACAGTG CAGCCAAAAG
16021 ATTGTCCTTA AATATGATGC GTTAGGATTT CCGCAGGACA ATCTTGAGAT TGCCTATTCG
16081 AGACGTCCAC AGCCTGAGTT CTCGCCTTAT CCGGATACCC TGCCCGAAAC ACTTTTCACC
16141 AGCAGTTTCG ACGAACAGCA GATGTTCCTT CGTCTGACAC GCCAGCGTTT TTCTTATCAC
16201 CATCTGAATC ATGATGATAA TACGTGGATC ACAGGGCTTA TGGATACCTC ACGCAGTGAC
16261 GCACGTATTT ATCAAGCCGA TAAAGTGCCG GACGGTGGAT TTTCCCTTGA ATGGTTTTCT
16321 GCCACAGGTG CAGGAGCATT GTTGTTGCCT GATGCCGCAG CCGATTATCT GGGACATCAG
16381 CGTGTAGCAT ATACCGGTCC AGAAGAGCAA CCCGCTATTC CTCCGCTGGT GGCATACATT
16441 GAAACCGCAG AGTTTGATGA ACGATCGTTG GCGGCTTTTG AGGAGGTGAT GGATGAGCAG
16501 GAGCTGACAA AACAGCTGAA TGATGCGGGC TGGAATACGG CAAAAGTGCC GTTCAGTGAA
16561 AAGACAGATT TCCATGTCTG GGTGGGACAA AAGGAATTTA CAGAATATGC CGGTGCAGAC
16621 GGATTCTATC GGCCATTGGT GCAACGGGAA ACCAAGCTTA CAGGTCAAAC GACAGTGACG
16681 TGGGATAGCC ATTACTGTGT TATCACCGCA ACAGAGGATG CGGCTGGCCT GCGTATGCAA
16741 GCGCATTACG ATTATCGATT TATGGTTGCG GATAACACCA CAGATATCAA TGATAACTAT
16801 CACACCGTGA CGTTTGATGC ACTGGGGACG GTAACCAGCT TCCGTTTCTG GGGGACTGAA
16861 AACGGTGAAA AACAAGGATA TACCCCTGCG GAAAATGAAA CTGTCCCCTT TATTGTCCCC
16921 ACAACGGTGG ATGATGCTCT GGCATTGAAA CCCGGCATAC CTGTTGCAGG GCTGATGGTT
16981 TATGCCCCTC TGAGCTGGAT GGTTCAGGCC AGCTTTTCTA ATGATGGGGA GCTTTATGGA
17041 GAGCTGAAAC CGGCTGGGAT CATCACTGAA GATGGTTATC TCCTGTCGCT TGCTTTTCGC
17101 CGCTGGCATC AAAATAACCC TGCCGCTGCC ATGCCAAAGC AAGTCAATTC ACAGAACCCA
17161 CCCCATGTAC TGAGTGTGAT CACCGACCGC TATGATGCCG ATCCGGAACA ACAATTACGT
17221 CAAACGTTTA CGTTTAGTGA TGGTTTTGGG CGAAACCTTA CAAACAGCCG TACGCCATGA
17281 AAGTGGTGAA GCCTGGGTAC CTGATGAGTA TGGAGCCAAT GTGGCTGAAA ATCAAGGCGC
17341 CCCTGAAACG GGCGATTACA AATTTCCCGT TGGGCAATTT CCCGGACGTA CAGAATATTA
17401 ACGGGAAAAG GCAAAGCCCC TGCGTTACGT TTCAAACCGT ATTCCTGAAA TAATTTGGGC
17461 AACTATGTCA AGTTGACCAA AAAATGCCCG GCAGGATATG TATGCCGATA CCCATTACTA
17521 TGATCCGTTG GGGCGTGAAT ATCAGGTTAT CACGCCAAAG GCGGGTTGCG TCGATCCTTA
17581 TTCACTCCCT GGTTTGTGGT GAATGAAGTT GAAAATGACA CTCCCGGTGA ATGACAGCAT
17641 AAAGCTCAGT GATGCCTGTT CACTGAACAG ACATCACTCC ATTTAGGAAT GAATCATGAA
17701 GAATTTCGTT CACAGCAATA CGCCATCCGT CACCGTACTG GACAACCGTG GTCAGACAGT
17761 ACGCGAAATA GCCTGGTATC GGCACCCCGA TACACCTCAG GTAACCGATG AACGCATCAC
17821 CGGTTATCAA TATGATGCTC AAGGATCTCT GACTCAGAGT ATTGATCCGC GATTTTATGA
17881 ACGCCAGCAG ACAGCGAGTG ACAAGAACGC CATTACACCC AATCTTATTC TCTTGTCATC
17941 ACTCAGTAAG AAGGCATTGC GTACGCAAAG TGTGGATGCC GGAACCCGTG TCGCCCTGCA
18001 TGATGTTGCC GGGCGTCCCG TTTTAGCTGT CAGCGCCAAT GGCGTTAGCC GAACGTTTCA
18061 GTATGAAAGT GATAACCTTC CGGGACGATT GCTAACGATT ACCGAGCAGG TAAAAGGAGA
18121 GAACGCCTGT ATCACGGAGC GATTGATTTG GTCAGGAAAT ACGCCGGCAG AAAAAGGCAA
18181 TAATTTGGCC GGCCAGTGCG TGGTCCATTA TGATCCCACC GGAATGAATC AAACCAACAG
18241 CATATTGTTA ACCAGCATAC CCTTGTCCAT CACACAGCAA TTAGTGAAAG ATGACAGCGA
18301 AGCCGATTGG CACGGTATGG ATGAATTTGG CTGGAAAAAC GCGCTGGCGC CGGAAAGCTT
18361 CACTTCTGTC AGCACAACGG ATGCTACCGG CACGGTATTA ACGAGTACAG ATGCTGCCGG
18421 AAACAAGCAA CGTATCGCCT ATGATGTGGC CGGTCTGCTT CAAGGCAGTT GGTTGGCGCT
18481 GAAGGGGAAA CAAGAACAAG TTATCGTGAA ATCCCTGACC TATTCGGCTG CCAGCCAGAA
18541 GCTACGGGAG GAACATGGTA ACGGGATAGT GACTACATAT ACCTATGAAC CCGAGACGCA
18601 ACGAGTTATT GGCATAAAAA CAGAACGTCC TTCCGGTCAT GCCGCTGGGG AGAAAATTTT
18661 ACAAAACCTG CGTTATGAAT ATGATCCTGT CGGAAATGTG CTGAAATCAA CTAATGATGC
18721 TGAAATTACC CGCTTTTGGC GCAACCAGAA AATTGTACCG GAAAATACTT ACACCTATGA
18781 CAGCCTGTAC CAGCTGGTTT CCGTCACTGG GCGTGAAATG GCGAATATTG GCCGACAAAA
18841 AAACCAGTTA CCCATCCCCG CTCTGATTGA TAACAATACT TATACGAATT ACTCTCGCAC
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Fig.2.

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18901  TTACGACTAT GATCGTGGGG GAATCTGACC AGAATCGCAT AATTCACGAT CACCGGTAAT
18961  AACTATACAA CGAACATGAC CGTTTCAGAT CACAGCAACC GGGCTGTACT GGAAGAGCTG
19021  GCGCAAGATC CCACTCAGGT GGATATGTTG TTCACCCCCG GCGGGCATCA GACCCGGCTT
19081  GTTCCCGGTC AGGATCTTTT CTGGACACCC CGTGACGAAT TGCAACAAGT GATATTGGTC
19141  AATAGGGAAA ATACGACGCC TGATCAGGAA TTCTACCGTT ATGATGCAGA CAGTCAGCGT
19201  GTCATTAAGA CTCATATTCA GAAGACAGGT AACAGTGAGC AAATACAGCG AACATTATAT
19261  TTGCCAGAGC TGGAATGGCG CACGACATAT AGCGGCAATA CATTAAAAGA GTTTTTGCAG
19321  GTCATCACTG TCGGTGAAGC GGGTCAGGCA CAAGTGCGGG TGCTGCATTG GGAAACAGGC
19381  AAACCGGCGG ATATCAGCAA TGATCAGCTG CGCTACAGTT ATGGCAACCT GATTGGCAGT
19441  AGCGGGCTGG AATTGGGACA GTGACGGGCA GATCATTAGT CAGGAAGAAT ATTACCCCTA
19501  TGGGGGAACC GCCGTGTGGG CACCCGAAAT CAGTCAGAAG CTGATTACAC AAGCCGGCGT
19561  TATTCTGGCA AAGAGCGGGA TGCAACAGGG TTGTATTACT ACGGCTATCG TTATTATCAA
19621  TCGTGGACAG GGCGATGGTT GAGTGTAGAT CCTGCCGGTG AGGCCGATGG TCTCAATTTG
19681  TTCCGAATGT GCAGGAATAA CCCCATCGTT TTTTCTGATT CTGATGGTCG TTTCCCCGGT
19741  CAGGGTGTCC TTGCCTGGAT AGGGAAAAAA GCGTATCGAA AGGCAGTCAA CATCACGACA
19801  GAACACCTGC TTGAACAAGG CGCTTCCTTT GATACGTTCT TGAAATTAAA CCGAGGATTG
19861  CGAACGTTTG TTTTGGGTGT GGGGGTACAA GTCTGGGGGT GAAGCGGCCA CGATTGCAGG
19921  AGCGTCGCCT TGGGGGATCG TCGGGGCTGC CATTGGTGGT TTTGTCTCCG GGGCGGTGAT
19981  GGGGTTTTTC GCGAACAACA TCTCAGAAAA AATTGGGGAA GTTTTAAGTT ATCTGACGCG
20041  TAAACGTTCT GCTCCTGTTC AGGTAGGCGC TTTTGTTGTC ACATCGCTTG TGACGTCTGC
20101  ACTATTTAAC AGCTCTTCGA CAGGTACCGC CATTTCCGCA GCAACAGCGG TCACCGTTGG
20161  AGGATTAATG GCTTTAGCCG GAGAACATAA CACGGGCATG GCTATCAGTA TTGCCACACC
20221  CGCCGGACAA AGTACGCTGG ATACGCTCAG GCCCGGTAAT GTCAGCGCGC CAGAGCGGTT
20281  AGGGCACTAT CAGGCGCAAT TATTGGCGGC ATATTACTTG GCCGCCATCA GGGAAGTTCT
20341  GAGCTGGGTG AACGGGCAGC GATTGGTGCT ATGTATGGTG CTCGATGGGG AAGGATCATT
20401  GGTAATCTAT GGGATGGCCC TTATCGGTTT ATCGGCAGGT TACTGCTCAG AAGAGGCATT
20461  AGCTCTGCCA TTTCCCACGC TGTCAGTTCC AGGAGCTGGT TTGGCCGAAT GATAGGAGAA
20521  AGTGTCGGGA GAAATATTTC TGAAGTATTA TTACCTTATA GCCGTACACC CGGTGAATGG
20581  GTTGGTGCAG CCATTGGCGG GACAGCCGCG GCCGCTCATC ATGCCGTTGG AGGGGAAGTT
20641  GCCAATGCCG CTAGCCGGGT TACCTGGAGC GGCTTTAAGC GGGCTTTTAA TAACTTCTTC
20701  TTTAACGCCT CTGCACGTCA TAATGAATCC GAAGCATAAC AATCATGTTC ATTCCCACTT
20761  TGTCATGGAT GACAAGGTGG GTTTTTCGGA TGTGTGGACA GAGACCCGTA CAGGGTCTCT
20821  GTCCAGTTAA TTTTTGGATC AAGAACGAAT GGTGTAACGG ATATGCAAAA TGATATCGCT
20881  CAGGCTGAGC AATAAGCTTT TCTGTTTACC ACTGATACCG GGAAAACTGA GGGTTAATGT
20941  GCCTGTATCG GCCACAGGAA GCCCTTCAAA TGGCAGGTAC TTAGCATCAT TGAAATCCAT
21001  CTGGAATTGA CCACTGTCAT TCATGCCATG TGAGATCACA ATCGCTTTGC AGCCACGTGG
21061  CATCATTGTA CTGCCGCCAT AACTCAGTAT TGCCCGGACA TCCTGATAAG GCCCTAAAAG
21121  GGCAGGTAAC GTCACACTGA TTTGTTTGAT ACGGCGTGTA TTACCTAAAC CGTCAGGATA
21181  ATCGGTAGCA ATATTCAGAT CCGATAATTT GAGGCTGGCT TGCAGTTGTG TCCCTTCGAC
21241  GTTCAAACCG TTAAGCGTTG TGCCTGCACT GCCTTCACCT GCATTGACTA ACTCAGTCAC
21301  TTTATCTTTT AAAATGAAAC TATTTTCTGT CAGACCAGCA TACACTTCAG CCAGAGAAAC
21361  GGTTCTGGTG ACCTCCAGTG CCCGTTCATC TTTTTCCAAA TAGCTTTTTT CCATCTGTGC
21421  TAAATTCAGC ATCAGGGTTT CACCCGCTAA TAAACCCGCA TAAGTCCCAT GCCAAGCACC
21481  TGGTTTAATA AAGTGTGCTG CCGCATTATT CAATTCATAC TGATAAGTTT GCTCTGCCAT
21541  TAAACAGAGT GAGACCGCCA AATCATAAAA CTGATAATAA ATAGCGGACA ACGTTCCACG
21601  GAGCCAGTTG TATAGCGCTG CATTACTGAA TTTACTTTGC AGAAAGGCTA ACTGCGCCTG
21661  AGTTTGTGCC TGCTGAGTTT CCAGATAGTT TTTTTGTAAT ACTGCCGCTT CACGACGTAC
21721  AGCCAGCGTC GCTAATTGAG CATCAATTTG TTTTATCTCA GCTTCCGCAT TATTGCGCTG
21781  AATTTCCCAC TCTTGCCGAC GGCGACGGTA TATTTCTGAT TGGCTGATTT TGTCTGCGGC
21841  AATACGTGTT GCTGACGCAG AAATTTCGAT ACCAATCGCA CTGGCATTGA AAAGCGCCCC
21901  AAAACGGGAA CCTCCCACAG CAAAACCGTA AATATTGGGG ACGAGATCTG CCGCGGCGGC
21961  GGCCATATGC AGGGCTGTGC CGCTGGTGCT CAAGACCGAT GAAGAGAGGT AAAGATCCAT
22021  CGCTTGTTTT TCACCAGCGT TAACATCTTC GTCGTACAGC GTATTGAAAC TGTCAAAACG
22081  AGACTGTGCA CCATGACGGC TTTCTTGAAG CGCCAATTTA TCAGCATCAA TTTCAGCCAT
22141  GACCTTATCC TGCATTTTAA TACTTTGCAG GGCTAACTCA CTGCCTTGAG TTTGCAGTAT
22201  TTCAGCCAAG GCTTCTGCAT CCTGCCGTTC AGTAATGCTG AGCAGGGTAT TGCCAAATTG
22261  TATCAACTGG CTTACCCCCC ACTTGGCATT TTCCAGAATC ACCGGAAAAC GGTACATCGG
22321  CATCACTGCA TGAGGTAAAT CGCCGCCGCC TTGTGAAGCA GTGATGGCAG CACTGAGTAA
22381  CATGGACGGA TCTGCGGGCG TGGCATAGAG AGATAATGAC AGTGGCTGAC CGTCGATTGT
22441  CAGGTTATGG CGTAAGTTAT AGAGGCGTTG CGTCAATGTC TGCCAGTAAC CTTGCAGTTT
22501  TTTATTAATT TGAGGGAGGA ACAATGCGGT TAACGAAATT TGCCGTACGT TTCGTGGGTA
22561  ATGCAGCGCG CTGACGCAGT TGCAGCATTT TATGTTGATA ATGATGCCGC ATTGTTTGGC
22621  TGGCAGCTTC TTCCAGCCGT GGCTCTGACC AATCGTTATC CAATGAAAAA TAAGGCTCAT
22681  CACCCAATAA AGTGAGCGCC TGTACATACC ACATTTTAGC TTCGTTTAAG GTATCACGTT
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Fig.2.

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22741 CAAGCTGGCG ATAGGCGCTA TCTCCGCGGG TAATCAACAA ATCCAGCATT TTCATAAAGG
22801 TAGCCACTTT ATAGTGCATC GGATCATGCT GGGCAACGGC GTCCGGATCG ACCGAATCCA
22861 GCGGATTGGC ATTCCAGGAC GTATCTTCCT CCAATGGGCG GACGTTCCAG TAATAATCCT
22921 GCATTTCACC CTGAACCGAA TATCCGGTCG GGTTCAGATA TAGCGCAGCC AGCGTGTCGA
22981 TCCGGTAAAA TCTGCTCTTG CAATAAGCGC TGGAATACCA TCATGGGCGT TGTAATAGAA
23041 CAATCCCAAG AAATAGATTG CATTGGCGCC GTTTGAAATC CATGGGTTCA GTGTTATTTT
23101 TCATGACACG ACTTGAATAC CCCTTTTATA TTTTTTGATA TTTTTTACTA TCCCCTGTTG
23161 TGTCATTCCC GAATCATGAT CGGCATCATT AGTGAATATA AATTGATTTT TCGTCTCATC
23221 AAAATAAAAG AAAGCAGATT CCCAGGATTT GTCATAGATA ATTTTTTTGT ACCCAACCCC
23281 TAATCTGACA CCTTCACGTA TGTAATATCC TTTAGCATAG GGAACAAAGA GCGTTACTGT
23341 GGTTTCAATA TCAGATAACA TTCCTTCGTA ATAAGGTTGT CTGGCAGAAT TGCCATCAAT
23401 ATTCCCAATA TGGATCTTAA ACCAACGTTC ATCACCATGC TCCTCTTTAT TGTAGGGGGG
23461 CAACTTAAAT GTCGCATAAA ACCCTTCACC TAATTGCGGC TCTGGTAAAT TTTGCGTTTC
23521 CATACTTAAA ACATTATCAA TACCAATATT GGCTCTTTCA GCTAATTTTC TGGAAAATAA
23581 AGTATTTAAC CGGGTTCTGT AAGGGCCAAT CTGCATATAT TGTGTGCCTG ATGGCATTTT
23641 ATGCAGTGAT ATAACGTTAC TTGTATCTTT GGATTTTAGT TTTATATGAA TTGGCGATTC
23701 AATAACAATA TCGTTATAAC CGCCGTCGGG TTGCTTAATA ATAAACTCGC TCACCAGAGG
23761 AATATCATAG CCTTCAATAT CAACTTTTAC TTGATTAAAA TCATATACCA TAGGGTCAGA
23821 TTCGTGTGAA GGTTTAGATG CCACATGGTC TTCAGCATTT AACTCCACTA GAATATCAGA
23881 GCCATTTTTT AATAAAAAAC TAATGTTTTT ATCTTGGATC TGTTCGATCA TAGATGAAGC
23941 AAGTTTTATT ATCTGTGGCT GGTTGAACAT AAATACACCC ATGGATCCTC GCGAAGGAAC
24001 AGTGCCGCAA TATTTCCCAT GTTATTAATG ATTGAAACAT CATTAGTAAA TGATTCACAT
24061 ATAGTATGCC ATACTCCTGT GTTATCTTTC CAATCTAATA CTATGTTAGT ATCAAGTTTG
24121 AATTCAGCAT CATCTGATTC ATAATCATAA TTTATACCAA CTCCAATTTC TGATTTTCTA
24181 GGAATTTTTT CCTTGGTTCT TAGATGCATT AACACTCTAA AATATTCGGC ATTTTTAAGA
24241 TCGATGGAAA TAATAAAATC CAAAGTTCCA TAATGAAAAA CTTCTTCTTC TTTTCCAAGC
24301 ATTTCATCAT GTCTATCATA ATCAAATAAA ATAACCGTTT CATCTTCTAC CATCGATAAC
24361 AGGTATTTAA CCTCATCATT ATATATATTG CCTTTTGAAA AATTAATTTC CATTGAAGGA
24421 TTGAACGTTA AATTAATATG ACCATTTCCT GGTGATATAT ACGAGAGATC AAAAATATTT
24481 CCGGTAAAAC TGGCTAATTT ATTTTTTGTG GTTATAGATT CCTTATATTC GGCCAAATAA
24541 TCTGTAGCAA ATTGATTGTT GACTTTGTAT TCTGTCCTGG TATCAAGTTC TGATAATGTG
24601 CTCTTAACAA TGGCGTCTAA ATCATTTTCT GTGAGAATGG ATAATGTCAT ATCAGGGTTA
24661 ATGGTCATCC CTTCTCTTGC AGGAAGACTA TTAAAAGAAT AATTGTCTTT TTTCTCATGG
24721 AAATAAACAA TAATGACGTC TTTTTCATAA TCAGAAGAAC AATACATACC AATGCTGGCT
24781 TTTTTATTGA TCAGGTTTTC TATTTTATCA GTCACATTAA AATTAAACGG TGAGCTCCAG
24841 CTGCCATCAT AACGAATATG TGACAGTTTT AATATATAAT CAGTGATATC TATCTTGCCA
24901 TCTTCACTTT CATTTTTCAG CTCTTTTTGT TCCAGCCACA GTAAATACAA ACGAGACTTG
24961 TAAATAACAG GTCTGATATT TTCCTGCCAT ACATTGATGG GTATTTCAAT TTTTTTCCAT
25021 TCTCCCCAGG CATTGGCAGC AAATTGACCG TGCTGGCACT TTTGGTGATC GACATTGCGC
25081 CAATAATATA TTCTGGGTTC TGTCTGGCTA TAACCAATTA AATAAGTGAG CCCCTCATTG
25141 ACATTAATAC TGTCATGATA TCCGCTAATC ACCTGCAAGT TAGCGACATC TTCAAATGCG
25201 GTCAGATAAT TTTTAAAGCT ATCTTCAACG GTATCGATAT TTAACTGACT TTGGGAAAGT
25261 TGCTGTAACA GGTTGTTCAT CATACCTGTC TGACCAATAC GAATCGTGGG GTCGATATAG
25321 TTTTCCGGAT AATAGGCCAG TTCAGATACG CCGGCCCAGG TGCTATACCG TCGATTGTAG
25381 GTTTCCCAGT CGCAGAAGAA CTGACGGGTT TTCACTGGCT TTGATACTTT TCCTTCAACA
25441 TTATTCAACG CCCGGTTGAC ATATAACTGA ATGCTGGCAA TGGCTTCTGC CACACGGGTG
25501 GTTTTCACTT GGGCAGAAAC TTGGTTATCA ATCAGCAGAT AGCTGTACAA CTCATCCCGG
25561 CTCTTAATCT GTTGAGGTGC ACCATTTTTG ATGTAGTAAG CACTGGCCGC TGTCGTCGTG
25621 GCTTCATCCA GCCATGCCTG AAGCTGGTCG GATTGTTGAC TGTTCAGTCC CGCCTGCAAC
25681 AAAGTACTGG CGGCTTGCCA ATCATCAAAT GTTGGCATCG GGGTTTCCGG TTCACCGACA
25741 TATTTTAATT TTATGAGTGC AGCAACACCA TCCGGGGTAA TACCCAATGT AGCAGCGACA
25801 TCCAGCCATT GCAGAGTGAC ATCTATAAGT TCTCCAGTTG GTAAAGGTAT TCACTCCCAA
25861 ACCGGTCTGT TGCAATGCTT GTGTCACAAC CTGAGCATCA AAATTTTAAC GCCACCGCCA
25921 AATTGTTCGG CAGTCAACGC TCCTAAGTTC CAAATGCTGT TAAGATTCTG TCGCGTAGCT
25981 TCACAACGCA TGATCACAGC ATGGAAGCGG GTCAGCGCTT GCAAAGTGGG GAGATCATGT
26041 TGCAGTGCTG TGGTTTCTGA TTGGAATTTC TCCGGTTTTG TCACCAACAG GGTCAGTTCG
26101 TTTTCGCTGA GTCCAATATT GCGCACAATC AGAGAAAGTT GCCCCAGTAC CTGACAAAAA
26161 GCCACCATGT TGCTGGTTTC ATTCTCTGAG CGATCACGGT TAGCCGCAAT AATCATGAAA
26221 TCATCGAATG TCAGTCCTTG TGGTTTTATC TGATTAATCC ACAGCAAAAT AGTTTCTGCT
26281 GTTTTGGCTG AATCCATTTG AATGCTGGCA GCAATCAGCG GGGCAGCTGC ACGGATCAGT
26341 TCGTCATCAC CGAGTGAAAG TGTTGATAAT CCATTACTTA GTGTCGTGAT AAGGTTTTCA
26401 ATATCCGGCG TAAGGACAGT GCTGTAATTA TCCGTGGTCA TCAGAAACAC ATCACTGACA
26461 GACCATTTCT GTGTTGTCAG CCACTGGGTG CATTGGAACA GAAAGCTGAT TAATTGCGTT
26521 AATGCTGTAT CAGAAAAAAG GGCAATTTTC GTGTTCACAT AGGGAGAAAC CGACAACAAC
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Fig.2.

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26581 ATGGATAATT CATTCACTGT CAGATGATGA ATGTCTGCCA GCAGACGAAC GCGATAAAGC
26641 AGAGACAGGT TCTCGATGGA ACACATAAAT TCTGGATTTG TTCCGCCATT AGCCAGTTTC
26701 CATAATGTAT ACAGTTCAGT ATCATTCACT CTGAAAGCAC GTTTCATTAT TCCCAAATAA
26761 AAATGGTTTT TTGATTCACC GGGGGTTAAA TCCAGTTTGG TATTATCAGC AGAAAACTCT
26821 TGGCCATTTA ATAGCGGTGT ATTGAACAGC ATTGTAAAAT GACTGGGTTG TTGTTTAGTG
26881 GAATATTGGC TGATATCTGA ATGACACAAT ACCAGCGCAT CGCTGACGCT AATATTATAG
26941 TGCTGCATAT AATATTGAAC ATAAAACAGC TTACCCAACA CATTGCTGTC AATGGTTAAG
27001 TCATCATAAA TACTTTCTAT TACTTGCCAG ATATCTTCTG GAGATATGCC TGTGGCTTTA
27061 TACAAACGAA TCGCTTTATT CAGCTTTAAC AGGAATATAT CACCGGGAAC TCCATCATTT
27121 TAAAGTGTGC ATTGGCATTG ATAGCATCCG ACGGATTTGG TTAACTCGCC ATAAGCGGAG
27181 TGTTATACCG TTGGTGATTT GCTCTGTCGT CAATTTAATG GGAATACTGT AATGGGTATT
27241 AGCAATGGGG ACGAAATTTT TATCTTGGTA TATATATTCT TTATCTCCAT TCTGGAGACG
27301 AAAATCCAAG TGGTCAGGTT CTGTTTTTTT TACACTGAAA TTATATTTGT ATTCATTTTC
27361 TTTGATTGGA ATTAGCTCTG CATAGTTTAA ATGTGAATCG TAGAAATCTT TGCGGGTTCG
27421 CTTAATCAAT CTTGCCGTTG CCGTATCATT CCCGTCATTG ACCAATGTTA TCAGTTGCTC
27481 ATTCTTATAC TGTTGATTTG TATTTTTCTT ACCGAAGGAG AGATTGACAA ATAAACTGAG
27541 TTCATCATAA GACAAATCGT AGTAGCGAGC CAAAGAAGCA TAACTCTTAA AAATCAGTAC
27601 ATCATCTGTA CCGAAATTTT TCTTCATCAG TTCTGTTGAA TTTTCCGGTG TAATTTCTTC
27661 TACAAGGATT TGATACAATT CAGGCGATAT ATCAGTCTTA ATAGCCAGTA GCGATGTTGG
27721 GTCCATTAAT TCCGCTACGT CTGTATTACG GCTAAATGCG GTGAGGTTTT TATCTTGCAA
27781 TAAAATTGCC TGACGGGCTG ACTCATACGG CAGATGATAG GGTGTCATGC CGGTTTGCCG
27841 GTAAGTGGAC AACATTTTCA TTACACCGTT ATAGTCAGTT TTCTCTAACG TCTGAATATT
27901 ATGCAGCAGT AATTCATTAG ATAAGGATAA TGTGGAAATT TCTTCATCCA TATTATTCTG
27961 TGTCAGTGCC AGTGAAGCAA TGTCGGGGCG TCGTTTATTC AGGTGATATT GAGAATTGTC
28021 AGGATGAAAA TCTTTCGCTT CCCGATATAA TTCTGTTAAA TAAGCCGCTG GTGAAAATAT
28081 GGAAGCAATT GATCCCGGTT TTACAAAACG GTGGGCGCGG CCATAAAACC AACTGTTGTA
28141 ACTATTGTTT AGGGTTGACG GTGTAATATT AAGGTTAGTG ATATTAGCCA GTTGTGGATT
28201 AGCACGGGAC AAAATGCGCA GTTCTTCAAG TTTATTCTGT TTTGATTCCT GATGAGCCTG
28261 TTGATATAAA AAGTCTGTTT CTCGCCACGT CAGAGTTCCA CTTGTCCTAT GACGAAATTC
28321 GCTGAAAGAC ATAAACGAAA TGTTTGTCAA TAATAAAGTA TCACCAGCCT TTTTCTATTT
28381 ATCTTATCTA ACAGTTCATT AACTTTTATC ATATAAATCC TTAAGTTATT GTCAATTTAA
28441 TGATTAATGG TTTTTAGGTG GAGATTATTA TAATCTGATA GGAATATTAT GGTTAATTAA
28501 ATTGATACTG ATTTATCGCT CTATTCTTTC AATAAAAAAT AAAGAACTTC CCTATAATAC
28561 ATGGATTTAA ATAATGAATA CCGTATGTTA AAAATTAAAT TTTAACAAAC TTTCATGAAA
28621 AAATTCAACT CAACAATTGT TTAAATATTT TTAATTGTGT TTGTGCTGTT TGAAAAATGA
28681 ATGACTAATA TTTATCTATG AAAGATTATT TATTGAGGAT GTCTTGCTTG GTTTCAGGGG
28741 GCTACGTTGG AGTCAGATAA ATGTGTGCAA AAAGAAATCC TTAATAAAGT TGCGTAATTA
28801 CAAAAGTTGG TATATCGTGA CAAGAGTGAT AGTAATGTCA CATAATTTAT TGAATACCCG
28861 AACCTCGCAA ATGCGGGGTT TTTCTTCGCA TAATCAAAGA GAAAGCTATG AAAAAAACAC
28921 TGATTACTCT TATTCTCAGT ACCCTTTCTT TTGGTGCTTT GGCACAGCAG GGTGGCTTCG
28981 TTTCCCCGGA CAGCACAGAC TATACTCAGG GTGGATTTAA AGGTCCAACT CCCAACCTGA
29041 CCAGCGTTGC TCAAGCAAAA TCTTTTCGTG ATGATGCGTG GGTTGTTCTG GAAGGAAACA
29101 TTGTTAAACA GGTTGGTCAC GAACTCTATG AATTCGCGGC CGCATAATAC GACTCACTAT
29161 AGGGATCGCT TATTACGGAC TTATCCGGAA AGCTATCTGG AACCCCTGTT ACGCCTGAAT
29221 AAAACAGAAT TCAGGGATAA CAGTGGTTCT GTTTATGTTG ACATTGATGA TAAGCGCTGG
29281 ATGGGTCTGA CGGCCACTCC AACTGACAAA GTTCGTATCG AAGGTGAAGT GGACAAAGAC
29341 TGGAACAGTG TTGAAATTGA TGTCAAAACT ATCCGCATAG TGAAATAACT CAAGCACTTT
29401 GAATATAGCC CCGCACTCGC GGGGTTTTTT GCTTTCTGGG AGTCGGAAGT TTAACCGTAG
29461 TGACGAGGAT CAAAACTAAG TTAACGGCAG TGGTCACTGA TTTGGTGCAT AAGTTATCAA
29521 AAGTTAAAAA TCAAAACTTA TTTTTTATTT AATAGAGGAA TGTCACCCTG TAGGTGAATA
29581 ACGTTGACGG ATGTAAATAT ACAGTATTAT AGTCCTTTGA TATGTTATTA AATTGAAAAA
29641 CCTTTAAACT ATATTCGGGG GAAATTATTA TGTCAGATGT TCGTAATATT ATTAATGTTG
29701 ATAACAATTT TGGTTGTGAA TATAAAGCGG ATTTATTTAA ATAAGTTTTC ATAATTGTGA
29761 TACACCCATT TTTCTCATCC CCGGTTTTTG CTGTTGTAAG GAAGCGGTTT CCATGAAGAT
29821 TTTGACATGG TTAAGCAACT GCCACATAAA TTGGCAGCAG TGGTTTCGTG TCACGGTTTC
29881 ATGCAAGGAT TGCCATAGAC GTTCAATTTT ATTCAACCAC GGGCAATAGG TCGGTAAAAA
29941 GAGAAGATTA AATTTGGGAT TCTTTGCCAG CCAAACCCTG ACCTTCCGGC TCTTATGAAT
30001 GCAATAGTTA TCTAAAATTA ACGTGATGGT TTTGGCATTA ACATATTGAT TGTTAATTTC
30061 ATCTAACAAT TTGATAAATA AATCTGAGTT CTTTCTCAAG CTACCGACAT AAGTGATTTC
30121 TTTCGTTTTC GCGTTGAGGC AATTGGCAAG GTAGTGTTTT TGGTTCTTTC CGGGGGTAAC
30181 AACACGCTTT TGTTGCCCTT TGAAGCACCA GTCTGCACCG ATTTTCGGGT TCAGGTTGAT
30241 GTCCACCTCA TCCTCATAGA AGACCGGGTG TTTCTCTTGA GGCATTGGAT AACGTCTCGC
30301 TGATTTTTGC CATTTTTTCA TCATACTCAG GGTCAGGCAA TTTTACGGTT GGTGCCGCCC
30361 TTCGCCAAAC GATGCCCGTC CGGCAAAAGT AGCGATAGAG GGTACTTTGA GAGAGCGATG
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Fig.2.

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30421 TATTCAGTAG CTCATTGATT TTAAGTGTAA TAAGCTCAAG GCTCCATCGT GAACGGAGAT
30481 AGCCAAAATG TTGTGGCGAG TGCTGTAATA AGAAAGAAAT GACTGTGAAG AGCGGAGCTA
30541 AGTTCCAGAT GGCAGGCCTT CCCGCCGGGA GGCTTTTAAG TCCTTCCAAC CCGTATAATG
30601 TTAACCAATT TACCCAACGA TGAACGGAAG AACGTGAACA GTGAAGCGTT CTGGAAACGT
30661 GAGAAACCGT ACTCCCTTCA TGTAACATCA AGAGCGCGGT GAAGCGACGT GCATAGTCCT
30721 TATCCCGGGT TTTCTGGATA GCTTTTTTCA TCGGACGTCG TTCATTTCGG GGTATTGATG
30781 TTATGATTGG CATGACTCAG TCCATTTTGG GATTTGTTTT GATTTGGCGA TTAATCAGAT
30841 CGCGAAAATC GGACTGAGTT CCCTTCAAGT GATCTACTAT TTTGAAATCT TATTTAATCA
30901 GGAGTCAGCA AATGAGTTAT TCCCCATAAT ACCTGACCAT GTGGTTGTTT ATCCGGGAAA
30961 TGATTCATCT ACCGGTGGTA TGTGGATTCC TTGGTGCGAT AGTCAGAAAG ATATTGACTC
31021 TGGCCATTAT ATCAAAGTTA CTTTCAGTAA AAAGGACGCT GCTGATATTG TGAACTACAT
31081 GTTTCAACAT GGCAGTTATG TTTATTTTAC AGACAGTAGT AAACAATTTA GCAATAAGCA
31141 AATTATGTCT GGTGATTCAG CTAAAGGCAA AGGGGATTAT AAGCTTGAAA TTAAAACAAA
31201 CGGGAACCTT CCACTGATGG TATTGAATAA ATATTGATTC ATTATTATTT ATGGATAAGA
31261 AATTAAGTTT ATATTTCATC TGGTTTCTGC AATTAAGTTT TAAAAATTAA TTCTACTTTT
31321 TTTATGGTTT TATATTTAAT GCCAATCATA TTATTTTTCT TATAATAATT GATAGTTTAT
31381 TTATATAGTA AATAAATTCT GTTGGATGTG ATTATTATTG TGAGACGGTA ATAATTAACA
31441 TAACAGAAAA TTCATGGTTA GGAAATTCAA TCAACTTTTG TCCGGTTTCC TGACCATGAA
31501 GAGCTGTATT TACTGTAGAA CTCGCATTGA TACTGGATTG ATTAGCCGGA CGAGTGTTGG
31561 GTCAGCAGAT AATATGTTGT ATATTGGCTG TGGATTTTTC AGCGAGATGA TAGCTTTGGC
31621 AGTAAAGGCG ATTAATAACC GATAAAACAG AGAGACGGAT TGTGGCCAGG AAAGCAAAAA
31681 AGCCTCACCA TGACGCGTTA TTCAAACATT TTTTAACCCA ACCAGAAACC GCCCGGGAAT
31741 TTTTATCCCT TTATCTGCCG GAAGCGATCC GGTCAGTGTG TGATTTACCA CACTAAAACT
31801 GGAACCGGCA GCTTTGTGGA CAGGCAATTA CGTCAGTTGC ACAGTGATGT GCTGTATTCT
31861 GTCGAGACAA CCCACGGGGA CGGTTACATT TATTGCCTGA TTGAACACCA GTCCACGCCT
31921 GATCCGTTAA TGGCCTGGCG GCTGATGTAT TATTCGCTGT CAGCCATGGC TGCGCATCTG
31981 AAAAAAGGAC ATACTGAACT CCCTTTGGTC GTCCCCCTGC TGTTTTATCA TGGTGAGGTG
32041 AGGCCTTACC CTTACTCAAA TCGATGGCTG GATTGTTTTA CACTCTCTGA ACACGCGGCT
32101 CACCTGTATA ATCAGCCCCT GCCGTTGGTG GATATCAGTG CGCTCAGTGA TGAAGAGATC
32161 CTGACACATA AAAGCATTGC CTTGATGGAG CTGGTACAAA AACATATCCG TTGCCGGGAT
32221 ATGCTGGAGT GGGTTCCCCA ATTGGTGGCG TTGTTGAATG CCGGTTATAA TAGCGCCGAA
32281 CAGCGCCATG TTGTGTTAAG CTATATTTTA CTGAATGGAC ATACGCTGGA TCTCGCCCAG
32341 TTTGTCCATC AACTGACTGA ACAATCTCCG GAGCATGAAA CCATGTTGAT GACTATTGCA
32401 GAACAGCTTG AACAAAAAGG GCGTGAGCAA GGCCGGACAG AAGGCAGAAC AGAAGGCAGA
32461 GCTGAAGGAC GGGAAGAAGG CAAGCTGGAA ACGGCGCGCG CATTATTACG GCATGGTGTC
32521 AGTCTGGACA TCATTGTCAC CAGTACCGGC CTGAGCCGGG AGAAAATTGA AGCGTTAAAG
32581 CATTAAATGG ATACGCTTTT TCACAGCAGG ATATGGTGAC CCCTGTGAGG CCACCGGAAA
32641 ATTTTATTTA CTACGATTTA CGACGGGTTA CTTTAGGAAG CTGAATGAGA CGTCCTTTGT
32701 TATATAACGG TCCCATATCA ATCTTCTCTT TTCCGCGTAC AGGTAAGTAA CCCAAACCTT
32761 CGTGAGCAGC ATTTGCCAAC AGGCCATCAT CCTGATCGCC TGACCAAGAG AAGATCCCGC
32821 CCAATTTCAT TTTGGTTGCA TAAATTCCCT TATGCAGCAC AGTGCGGGGC GTATCCAGTG
32881 AAATCCAGTG ACCACCGTCA GCATTAAAGA GTGCGTCAGC GTCGGTTTCC GTGTCTGTCA
32941 CCAGTTCAAA CTGATTTTTC CCGCGTGCAA TTTCATATTC CGCATCGTAT TGGTTATTCA
33001 GCAGACAGAA GAATTCCGGA GCACCTTTTT CCATCGTGCC CAGTGGCTCT CCTGTTCTGT
33061 TATAGCGGCG CGTTGTCAGA TCAGCACCCA GACATGAACG TCCATAGTTA GCAAATCCGA
33121 GGTGAATTTT CTCCGGTTGT ACACCTTGTG ACAGTAAAAA GCGGATCGCC TCATCTGCCG
33181 AGTAATCCAT GTCCCGATCA GGATTGGGCG GAGGAGGGTT ATCGCCGTCA TATTCATATC
33241 TGGGGGGATA CAGGTTAGTA TGGTGACCGA TGTATTCTGC CCAACCGGTA CCAAAGAAGT
33301 CGTAGGTCAT CACAAAGATA TTGTCTAAAT AAGGTGCGAT TTCTTTGAAG CTGGACTTCT
33361 CCATTTTGGC AACGACGGCG CTACAGGCTA TCGTGATTTC TTTACGGGCC CGGGTTCCAA
33421 AGGCGATGTT CAGTGCTTCA CGCAGCTCTT TCACTAACAA AACATAGTTT GGGCCATCAT
33481 GTTCCGGGTC GAATTCATTA CCTTCTTCAC CTGTGGCGCC GGGGTATTCC CAGTCGATAT
33541 CCACCGCAGT AAACATGGGA AAACGCCGGG AAGAAGTCGA CGATGCTACT CACAAATGTA
33601 GCACGTTGCT CAGGATCTTT GGCCATCACA GAGAAATACC CTGACATACT CCAGCCGCCG
33661 ATACTGAATG CGAGTTCCAG CTTATGCCCT GCCTGTTTTG CTCGCGCTTT CAGATTACGC
33721 AATCCCCCCA GTAAACCGGA GGCTGCATCC TGATTGTAAT ATTGCAAGAA ATTCTTCGGG
33781 CTGGCATCAC GGCGCTGATC CGCGTCCAGA CCGACATTGC GTGTGGTGCC TAAATCACCA
33841 TAAGGATCAA CGGGTACAAT ATGGCCTAAT GTAATAGGGG CAATCTGGCC ACTGCTGGCT
33901 TCTGCTTGCC GGTTCCACCC GTCAACAACC TCATTAATCC GTTCGGATAA CTTGCCTTTG
33961 TCACCGTTGA CGGCCATAAA ACTGAAAATC AGGCGGTCGT AGGCGGTAGG CGGGATTTTT
34021 TCCAGATCAA AACCACGGCC GGGGGCATCG TCGCTGGTCA GCGCAGTGTT ATCCTGGGTT
34081 TCTGGCGACA AACGCGCATC ATACTGGCAC CAGTCAGTAA TATAGGCAGA GACTTTAGGC
34141 AGCGGTTCTG TATTTTCCGG ATCAACTTCA TATTCGTTGT ACAGGGACTT GGCAACACGT
34201 GCTGAAGAAT AACTCAAAGG AGTTCCGCTG CCGTCAGGTT TATATCCCAC CTTCTGATAG
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Fig.2.

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34261 GTTTCTTCTG TGAGTGCATC ATATTGCAAT ACCTCGGTTT TTTCTCCCGG CGGTACATCA
34321 GGCGTATTGG GGTTACCGTG ATCGGCAATT TCTTCCGGTG TCGCCTCACG GACATATTGC
34381 CAGGCATTCT CATAAACCGG TAAATCAGGT GAAATATTGC GGTCGGGAAT ATGCCAGCGT
34441 TCAACCCAGC CGATGTTTTT AAAAACCGCG CTATCATAAA TGACATACCA GGTTTGACCA
34501 CCAGATTGAT TCTGCCAGGC AACCAGAGAT GCGCCTACTT CGCTGCTGGC GTCAGACATC
34561 GCTTTAATTG AAGGGTATCG ATAAACATTT TGAGACATAA TTTCACTTCC GGCCCCGTTA
34621 TATTCCGGGG CCGGCTCCTG ATATCAGTTA GAATTGTCTT GTTTTAATTG ATGTTTATTC
34681 AGACGGCTAC GAACCTGCTG GCTGAACTCA TTACTTCCGC CACTCACATC ACGCGCGGTA
34741 TAACGCAGAT GGAGGATAAT ATCGCTCAGC GACTCCAGCA GCTGATCCTG ATCGGAACCG
34801 AATTCCAACT TCCACTGTGA AATGGCGCCT GTCCCTTCAA AAGGCAGGAA AAGTTCATCA
34861 TCAAAATTGA GCCTGAACAT GCCGCTGTCT TCCATGGCCG TTGAAATCAC CACACCTTGA
34921 TTAGCCTGTA CGTTCAGCAA AACGTTTTCG GGTTTGGTGT ATTCCAAGGG GTTAAGCAAA
34981 TAATCGATAG TTTTTAAGTC AGCAGTACTG TAAAGCGTAT TGCTGAGTTG TACCAGTGAA
35041 GCCCGTACAT CTTCATAAGG CCCCAGCAAT GCGGGCAATG ACAGCGCTAC GGTTTTTATA
35101 CGCCGATCAG CGTGGGTCGG ATAATCGCGC AAGAACATTT CGGCGCTCAG TAAGAAAGTG
35161 AATGAACCCG TACTCTTGCC AATTTCCCAC TGTGATGATG TCAGTAATGA TTTTACCGAT
35221 ATGGTTTTTA TGATCTCCAG ACGTCTGGTG TTATGTTGCA AATACGCCTG ATCCATCCGT
35281 TGTAAGGCTA ATTTCAGATG TTCTCCGACC AGCAGCCCCT GATAAAGATC ATTCCAGAGA
35341 CCACTTTGGA CGAAATTCAT ATCATACTGA CCTGTTTCGT ACTGCCAGGA GGCTTCGGCC
35401 AGTAAACAGA GGGAATTAAC CGCATCATAG GCTTGCAGGT AAAGCCGGAG ATTTGGCTGA
35461 TCATCCACAT GTATAACGCA TCATTGGTAN ANTTGTTCNN NNNNNNNNNN NNNNNNNNNC
35521 CCGAAGCATA CCGCCAAGAC CATCCCCCCG ACGGCCAGAC CGAAAATATT GGGAACCATA
35581 TCCGCCACAG CGGCCGCAGT GGCGGCTGAC TGGGCAGCGA TCACACCTTC AGCCGCTCTT
35641 GATTGTAATG CGATAACTTC CTGCTCGGTG ATGGAGATGT TTTCATCATA GAGCGATTTA
35701 TAGTGTTGCT GGCGCTCCTG AGCGGCCCGT CGGCTGATGG TCAGTGCATC CAATGAAGCC
35761 TGTTGCATGT CAATCGCTTG CTGTTGCAGA TTGCGGGTAA AGCTGTACAG CCCCAGTTGC
35821 TGCTGCATAC GGAAGTGTTC AAAATCGGTA TTGTCTTTTT TCTCCAGCAA ACTCAGTAAC
35881 GTGCTGCCGT ACTGAATCAG CGTTTCTGCG GCCTCTTTTG CCCGGCTCAT GATCGGGGTG
35941 AAACGATAAT TCGGGATTGC CCGGCGTTTC ATGCCCGCCA TACGATTAGC CACAACACGC
36001 TGGTAACGCT GCCTGAGCAG ATCTTGCGGG CTGATGGGTT CATCGTATAA TCCGGCCGGA
36061 AACTCTTTAC CATCCAAGGT CAGGTTATGA CGTAAGTTAT ATAGACGCTG ATCCAACATT
36121 TGCCACAGTT TGAGATATTC CGTATCAACA GGTTTGACAA ATAAATCAGA CGGTGCGGCA
36181 GAGACGGATG TATCATATGT CACAGGCAGA AGTGGCACGT TGCTGACAGT AAGCATTAAC
36241 TCCTGTGCCC GTGCTTCACT GTTTTCATAC AGAGCCACAT CTTGCAGCGT ACGGGGTTGC
36301 CAGTTTGCCG CGAGCAGAAT ATCAGGGCTG GTACCCAGTA ACATATTGAC GGAGTCATAG
36361 ATCTGCTTGG CGACAGTACG TGCACTGGAT GTCAGCTTAC GGTATTCCAT GTCTCCCTGA
36421 TCTAACAGAT TCTTGACATA GAAACGGAAT ATTGCTTTCC GGTAGTGAAT GGGTTCACTG
36481 GCTGCAATGG CATCCGGATC GGTTGGTTCA ATTAACATCC GGTACACGGT GGGTGGAGGA
36541 TCAATAATTG GCCGTGAATT CCAGTAACGC GGTTTACCTT GGTTGCTGGC CTGAACAAGT
36601 TCATCTTCCA GCGGATTAAA AATATAGTGC AGCCATTCGG TGGCCTCTTT TAATCGTTGT
36661 TCTATATTCA GTCGCCACGC GACCAGAAAT GGCATATGGA AAAACAGTTC CCAGAAATAG
36721 ATCCCATTTG CGCCATTTAA ATCAATCGGC GTAGGGAATG AACCGGGTAT AGGCTGTTCG
36781 GTAATAAGCT GTGTATTCCA GCTCAGTACC TGCGGGATAC CCTGACTGGC AATGGCGATC
36841 AGTTTTTTTG CAAACAGTGT ATTAAGGCGA ATGTTTTGTG GCGCGTTATC AGTTTCATCT
36901 GCGGGGAAGG AAAGGAATTG CACCTGATCC TGTTCATTGA GTTTAATCAG TTCGCGAATA
36961 TGCATACCGA TTCTGAACTC TTGAGTACAG CTGGCACTTT CATTGCCAAC ACCACCTTTG
37021 GGCTTAAAGA GAAGTTCGGC TTTCAGGGTG ATTCGATTAT CCGACCCCAG CTTGATTGAT
37081 GGATAGGTTA AATCAAGAAC TTTTTCGCTC AGTACCAGTG GTTGTTCATC CAAGACAGTA
37141 TTATCGTGCA TCAGCCGGAA AGAACCGTTG TAATATTGAT GATCTTCTAT CGCACCAAAC
37201 TTAAAGTCAG ATTGAGCGAC AATCTCCAGT GTGTCATCAG TGCCATGAAC AAAATTGACA
37261 ATCAGTTTGA TACTGTCTTT GCCGAAATCA GGGTTCATTC CGGTTTGGAT TCTCCGGCAA
37321 TAGGAAAGCG TTCTTCCCGG GTTGCCGGAT AGAGCACCAT AGTACGGTAA TCGATAGGAT
37381 TGCCTTAAGG CATCCTTGTG TTCACGTGAG TAATACCAGA CCAGGTTGCC GACATATTTT
37441 CCTTTTCGTC CATCAGCATA TTGGTCATCC GGCAAATCAG TAATTTCTAC CAGCAGTGTA
37501 TCGCAGACAT AACCGAAGGC TTCGTCATAA TCATAATCCT TACCTTTCTT ATCTGTCCCC
37561 TGAAGACGGA CAAACGGAAC CAGAGCCAGA AACGGGTTAT GCGGGTCTTG CTGTATATCC
37621 ATCACAGCAA CCATCTGGGC CATCCGGTAT TGCAGATGTC TTCGCGCAGA ATGGTGGGTG
37681 TACTCCAGCT GCCATCATAT TTGGCATAAG CGATTTTGAT CCGGTCAGGA ACGGTGTGGG
37741 AGGAACCCAA TCACCCGCAC TAGGCTCAAC GTTTTGGTTA TGCAGTGATA ACGCAGTTGT
37801 ATCTTTAGTT TCAGACTGTT CTTCAACTTC CGTCCAGGCA ATATACAGGC GATTATTCAG
37861 GAAAATGGGG CGTATCAAAT TGGGGTCTAC GCTGCCCAAT GGCAGGTCAA TAGGTTTCCA
37921 CTCGCTCCAG GCATTGGGAG ATAACGCATC GGTATCAGGA TGGCGTATCG AAAGATTCAG
37981 TGAACGCCAG TAATATTGGT ATGGCTGTGT ACGGGTACGT CCGACAAAGA AGAACTTATC
38041 GCGTTTGATG TTAACACCAT CTTCATAACC TGCGATAACT TTCAGGTTAC TGACATCTTC
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Fig.2.

```
38101   AAAATTATTC AGATAACCGA GCACCGCTTG TTGTACAGAA TCTTCGGTAA TTTTTCCCTG
38161   ATTAAGGGCA CTTTCCAGTT GGAAGAAGAA TTCTGTTTTA TTCAGGCGTA ACAGGGGTTC
38221   CAGATAGCTT TCCGGATAAG TCCGTAATAA GCGATCCC
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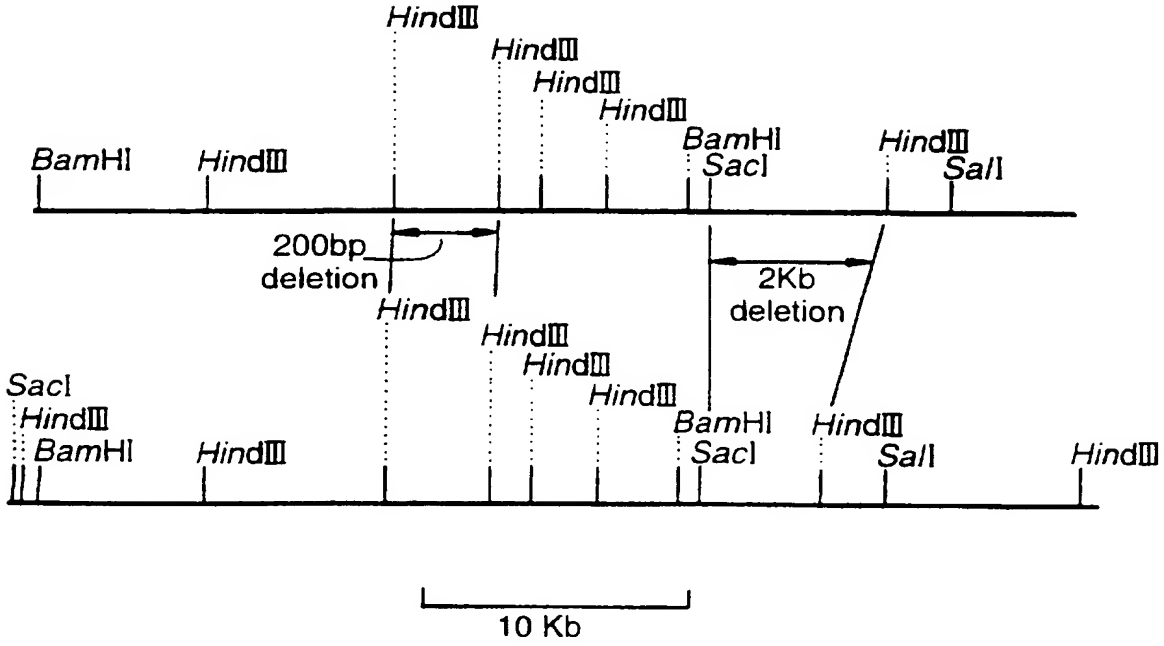
N=unspecified base

Fig.3.



INTERNATIONAL SEARCH REPORT

rnational Application No
PCT/GB 97/02284

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A01N63/02 A01N63/00 C12N1/20 C07K14/24 //(A01N63/02, 63:02,63:00),(A01N63/00,63:00)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 00647 A (COMMW SCIENT IND RES ORG ;SMIGIELSKI ADAM JOSEPH (AU); AKHURST RAY) 5 January 1995 cited in the application	1,5,11, 13, 18-21, 24-26, 29,30,32
Y	see page 1, line 3 - line 29; claims 10-13	3,4, 6-10,12, 14,27, 28,31

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[X] Further documents are listed in the continuation of box C.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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P,X	US 5 616 318 A (DUDNEY RALPH A) 1 April 1997 see column 1, line 65 - column 2, line 52 see column 5, line 3 - line 4	1,4-6, 11,13
T	WO 97 17432 A (WISCONSIN ALUMNI RES FOUND) 15 May 1997 see page 2, line 31 - page 3, line 23 see page 5, line 1 - line 16 see page 8, line 23 - line 33 see page 9, line 41 - page 11, line 14 see page 17, line 1 - line 21	1-32

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International Application No
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With international search report.
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(54) Title: PESTICIDAL AGENTS

(57) Abstract

A method for killing pests (e.g. insects) comprising administering material from *Xenorhabdus* species (e.g. *X. nematophilus*) such as cells or supernatants orally to the pests, either alone or in conjunction with *Bacillus thuringiensis* or pesticidal materials derived therefrom. Also disclosed is an isolated pesticidal agent (and compositions comprising the same) characterised in that it is obtainable from cultures of *X. nematophilus* or mutants thereof, has oral pesticidal activity against *Pieris brassicae*, *Pieris rapae* and *Plutella xylostella*, is substantially heat stable to 55 °C, is proteinaceous, acts synergistically with *B. thuringiensis* cells as an oral pesticide and is substantially resistant to proteolysis by trypsin and proteinase K. DNA encoding pesticidal activity is also disclosed.

*(Referred to in PCT Gazette No. 29/1999, Section II)

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Fig.1.

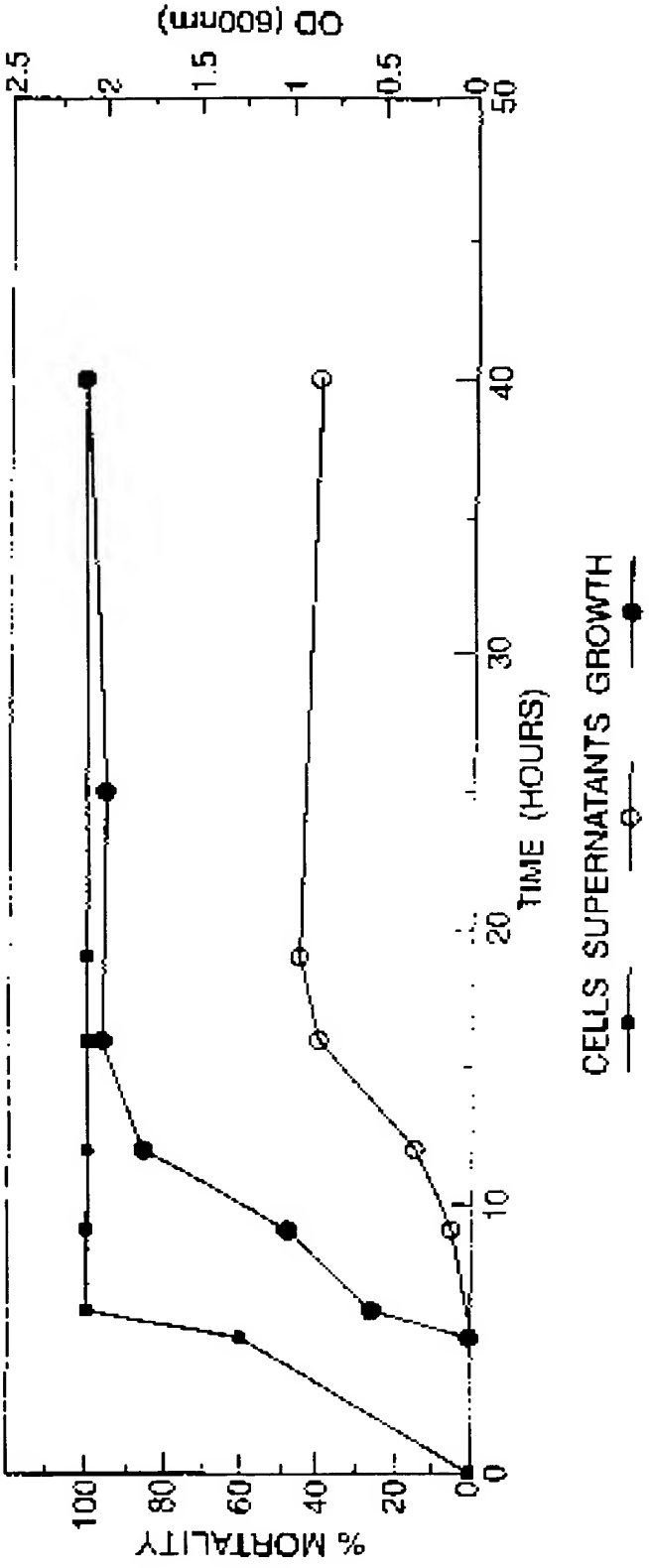

Fig.2.

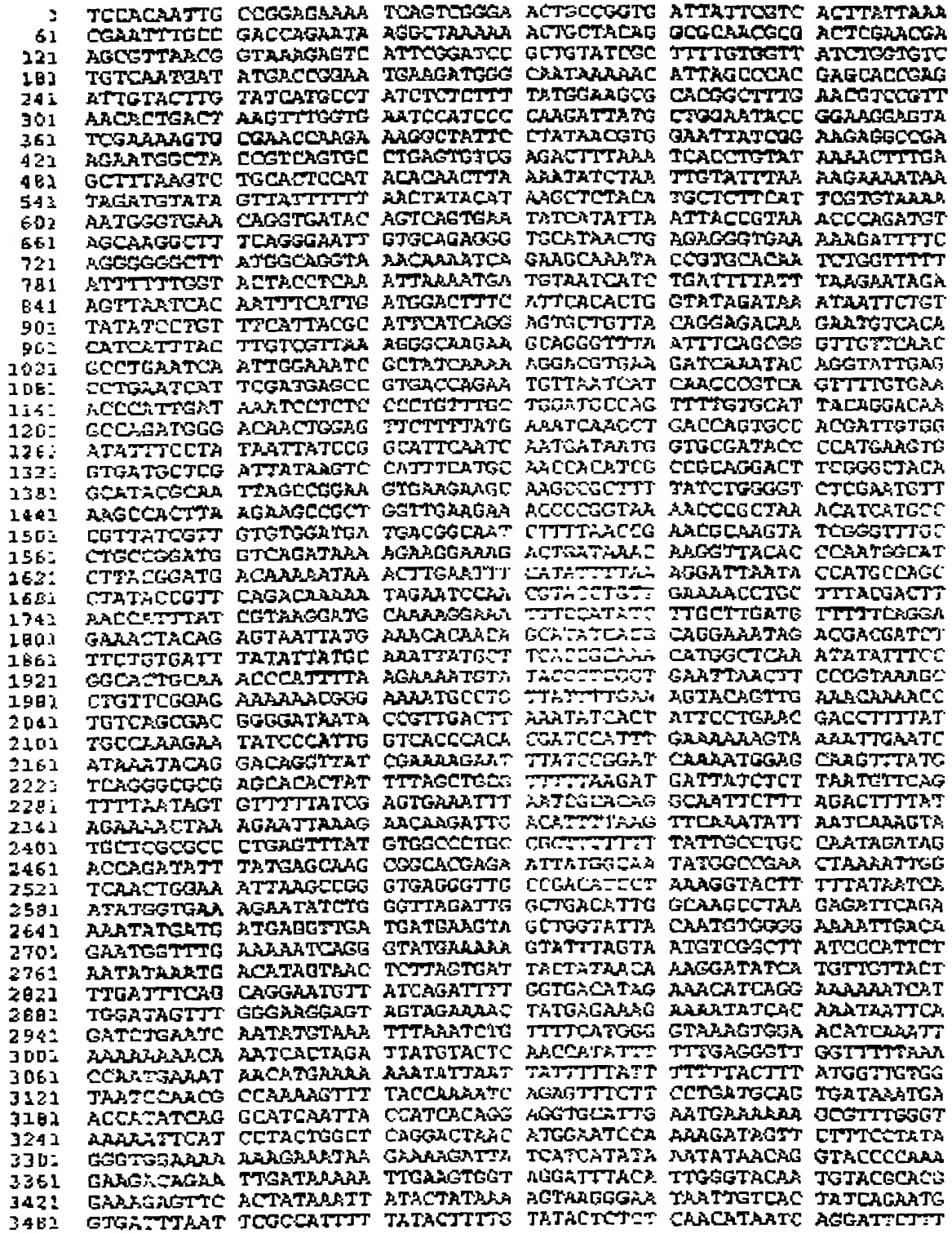

Fig.2.

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3661  ATGAACTCGA AGATAATCCT TTCTGAGCCT GAACGAATCA CATTGCAACC ACTCGCTTTG
3721  AATCACCCAC ACGGGACAT TGGTACGCGA GGAACGGGTT TACTCATGCT TGCCAGAGGG
3781  AGCAAGCCGT CCCAGATCAC CGCTGAAATC GGATGCAGTC TCCGGGTTAT CTGTAATTGG
3841  GTTCACATGT GGCACAGATA GCGGGATTAT TCGGCGGTCA TGCCGGAGGC CGGTATCTCG
3901  CCATGACGCC TGACATGATT GCCACTGCGC TCGAAGCCGC CAGCGCAGAG TCCCTGACGT
3961  GCGTCGAAGC CAGGCAGGGT TTCCCTGCCT TGTACGCTTG AAACGCTGGC GAATACCCTG
4021  AAAAAACAGG GGCTCCCCTA TAAACGCCCC CGCCTGTCGC TTAAAAAAAG CGCAATAAAA
4081  CGGAGTTTGC TGAAAAATCC GCCTTGCTGA ATAAAATTAA GGCCGGAGCA CAGTCAGGAC
4141  ATTACCGTCT GGTCTATTTT GAGTTCTGAG GGCGTTAAAT TACACGGATA ACACGCTGTT
4201  TTACCAGACA ACGTCAGGCA GTATCACGCG AGATGACGTG ATTGATTTTT TAGAGCCGGT
4261  GGCCAGACAA GGGACAACCG CCTGACATTT TTAGTGTTGG ATAATGCGCG TATCCATCAC
4321  GGGATAGAGG AAAAAATCAG AAATGGCGGG TGACGAGAAC ACAACCTGTT TTTATTCTAT
4381  CTTCCCGCTT ACAGCCCAGA GCTGTATCTG ATTGAAATCG TCTGGAAACA GGCCAAATAC
4441  GACTGGCGAC GTTTTATCAC CTGGACTCAG GATACAATGG AATATGAGGT AAATACTTTA
4501  TTGAAAGGTT ATGGCGACCA ATTTGCAATT AACTTTTCTT GAGTACTTAG TAAGAATAGA
4561  GTCAGTCGAG GTTTTTTCAT TTCGGGTCGT GGGGATGATA CTGAAAATTT GTTTGTAATC
4621  TCTCAAAATT GCTGTTTCTG TGGCTACGTC TGTCTTTTGC GATATTGTTT CCATCAAGTC
4681  TGTCAACATA CTGTTAAGTT AGATGTTGAT AAAAGAGACT GAATTATAAT ACAAAACAAT
4741  AAATCACTTG GACAATATTT TATTTCACAT GAGACATTAA GGTTGATTTT CCCAATCTGG
4801  TCAGTTATAA CCGAATAAGG ATCTTGAAAA ATCATGGGAT CTTACTTTTA TCAAATGAAG
4861  TTAACGTAAA AGTTGATAAA GAAAATTATT TAATTCTAAG TGCCGTTGGC ATAAATATTT
4921  TGTGTTTTGT TAATGAATGA ATAACCAGGT AAGCTGGATT TTCATTTTTT AATTACTCGT
4981  TACAATATGC TATTTATTTA TATAAAGAGT TTGTGCCCAT TTAACCAGTA AACAAATTTG
5041  TTCAACCGTA ACTTAGCTTC ATCGACTTTT GGCCTCGCCT GGTCAGAATC TAGGGCCGTT
5101  ATCCTATTTA TTTATGATAA ATAAAATTTA ATTATCTTTA ATAAGCTGAA TATGTGGATT
5161  TGTGCTCAAT CTTGGATTCA AGTATGTATT CCTTTTGGTA CCCTGCTTTA TTTTAAGGCA
5221  GATGAAGAGG ATGCCAACAT GACACAATAT CGATTACGAC TGTAACATTA AAGTCAGTTA
5281  TAAATTTTAT GATTAAAATG AAATTTTAGT AGAAAATCGT ATTCTATTCC GCCATTTACA
5341  ATAGCATCCT CTTTAATATC ATTAATCTCA GATAAAACAA ATAATTACAA TGTGAATAGA
5401  ATAATCACTT ACAAAATAAG CACTAAATCT TCAGATGAAC TCTTAACTGA CAACACTATT
5461  TTATAAAATA ATTGAGGTTA TTATGTATAG CACGGCTGTA TTACTCAATA AAATCAGTCC
5521  CACTCGCGAC GGTCAGACGA TGACTCTTGC GGATCTGCAA TATTTATCCT TCAGTGAACT
5581  GAGAAAAATC TTTGATGACC AGCTCAGTTG GGGAGAGGCT CGCCATCTCT ATCATGAAAC
5641  TATAGAGCAG AAAAAAATA ATGGCTTGCT GGAAGCGCGT ATTTTTACCC GTGCCAACCC
5701  ACAATTATCC GGTGCTATCC GACTCGGTAT TGAACGAGAC AGCGTTTCAC GCAGTTATGA
5761  TGAAATGTTT GGTGCCCGTT CTTCTTCCTT TGTGAAACCG GGTTCAGTGG CTTCCATGTT
5821  TTCACCGGCT GGCTATCTCA CCGAATTGTA TCGTGAAGCG AAGGACTTAC ATTTTTCAAG
5881  CTCTGCTTAT CATCTTGATA ATCGCCGTCC GGATCTGGCT GATCTGACTC TGAGCCAGAG
5941  TAATATGGAT ACAGAAATTT CCACCCTGAC ACTGTCTAAC GAACTGTTGC TGGAGCTATT
6001  ACCCGCAAGA CCGGAGGTGA TTCGGACGCA TTGATGGAGA GCCTGTCAAC TTACCGTCAG
6061  GCCATTGATA CCCTTACCA TCAGCCTTAC GAGACTATCC GTCAGGTCAT TATGACCCAT
6121  GACAGTACAC TGTCAGCGCT GTCCCGTAAT CCTGAGGTGA TGGGGCAGGC GGAAGGGGCT
6181  TCATTACTGG CGATTCTGGC CAATATTTCT CCAGAACTGT ATAACATTTT GACCGAAGAG
6241  ATTACGGAAA AGAACGCTGA TGCTTTATTT GCGCAAAACT TCAGTGAAAA TATCACGCCC
6301  GAAAATTTCG CGTCACAATC ATGGATAGCC AAGTATTATG GTCTTGAACT TTCTGAGGTG
6361  CAAAAATACC TCGGGATGTT GCAGAATGGC TATTCTGACA GCACCTCTGC TTATGTGGAT
6421  AATATCTCAA CGGGTTTAGT GGTCAATAAT GAAAGTAAAC TCGAAGCTTA CAAAATAACA
6481  CGTGTAAAAA CAGATGATTA TGATAAACAT GTAAATTACT TTGATCTGAT GTATGAAGGA
6541  AATAATCAAT TCTTTATATG TGCTAATTTT AAGATATCGA GAGAATTTGG GGCGACTCTT
6601  AGGAAAAACT CAGGGACAAG TGGCATTGTC GGCAGCCTTT CCGGTCCCCT GGTAGCCAAT
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6721  AAAATATATG CCTATCGCTA TACGTCTTCC ACCAGCGCCA CAAATCAGGG CGGCGGAATA
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6961  CACCGTTATG CACTGAGCTT TGATGATGCA CAGGTACTGA ACGGATCGGT CATTAATCAA
7021  TATGCCGGAC GATGACAGTG TCAGTCATTT TAACCGTCTC TTTAATACCC CGCCGCTGAA
7081  AGGGAAAATC TTTGAAGCCG ACGGCAACAC GGTCAGCATT GATCCGGATG AAGAACAATC
7141  TACCTTTGCC CGTTCAGCCC TGATGCGTGG TCTGGGGATC AACAGTGGTG AACTGTATCA
7201  GTTAGGCAAA CTGGCGGGTG TATTGGACAC ACAAAATATC CTCACACTTT CTGTCCCTGT
7261  TATATCTTCA CTGTATCGCC TCACGTTACT GGCCCGTGCC CATCAGCTGA CGGTTAATGA
7321  ACTGTGTATG CTTTATGGTT TTTCGCCGTT CAATGGCAAA ACAACGGCTT CTTTGTCTTC
```

Fig.2.


```
 7381  CGGGGAGTTG TCACGGCTGG TTATCTGGTT GTATCAGGTG ACGCAGTGGC TGACTGAGGG
 7441  CGGAAATCAC CACTGAAGCG ATCTGGTTAT TATGTACGCC AGAGTTCAGC GGGAATATTT
 7501  CACCGGAAAT CAGTAATCTG CTTAATACTC TCCGACCCCG TATTAGTGAA GACATGGCAC
 7561  AAAGTAGTGA CCGGGAGCTT CAGGCTGAAA TTCTCGCGCC GTTTATTGCT GCAACGCTGC
 7621  ATCTGGCGTC ACCAGATATG GCGCGGTATA TCCTGTTGTG GACTGATAAC CTGCGGCCGG
 7681  GCGGCCTGAA TATCGCCGGA TTTATGATGC TGGTGCTGAA AGAGACGCTG AGTGATGAGG
 7741  AAACGACCCA ACTGGTTCAA TTCTGCCATG TAATGGCACA GTTATCGCTT TCCGTGCAGA
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Fig.2.

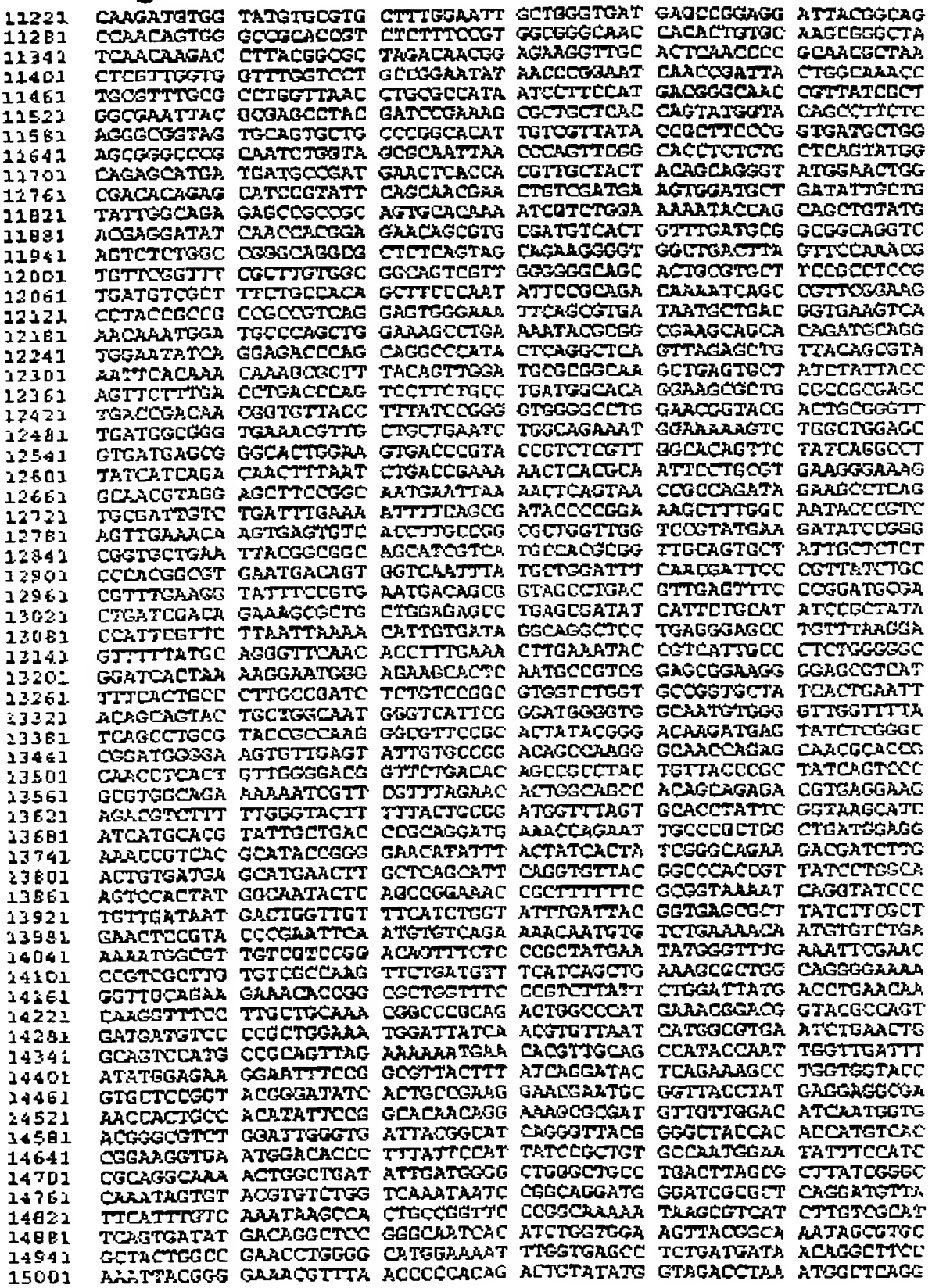

Fig.2.

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Fig.2.

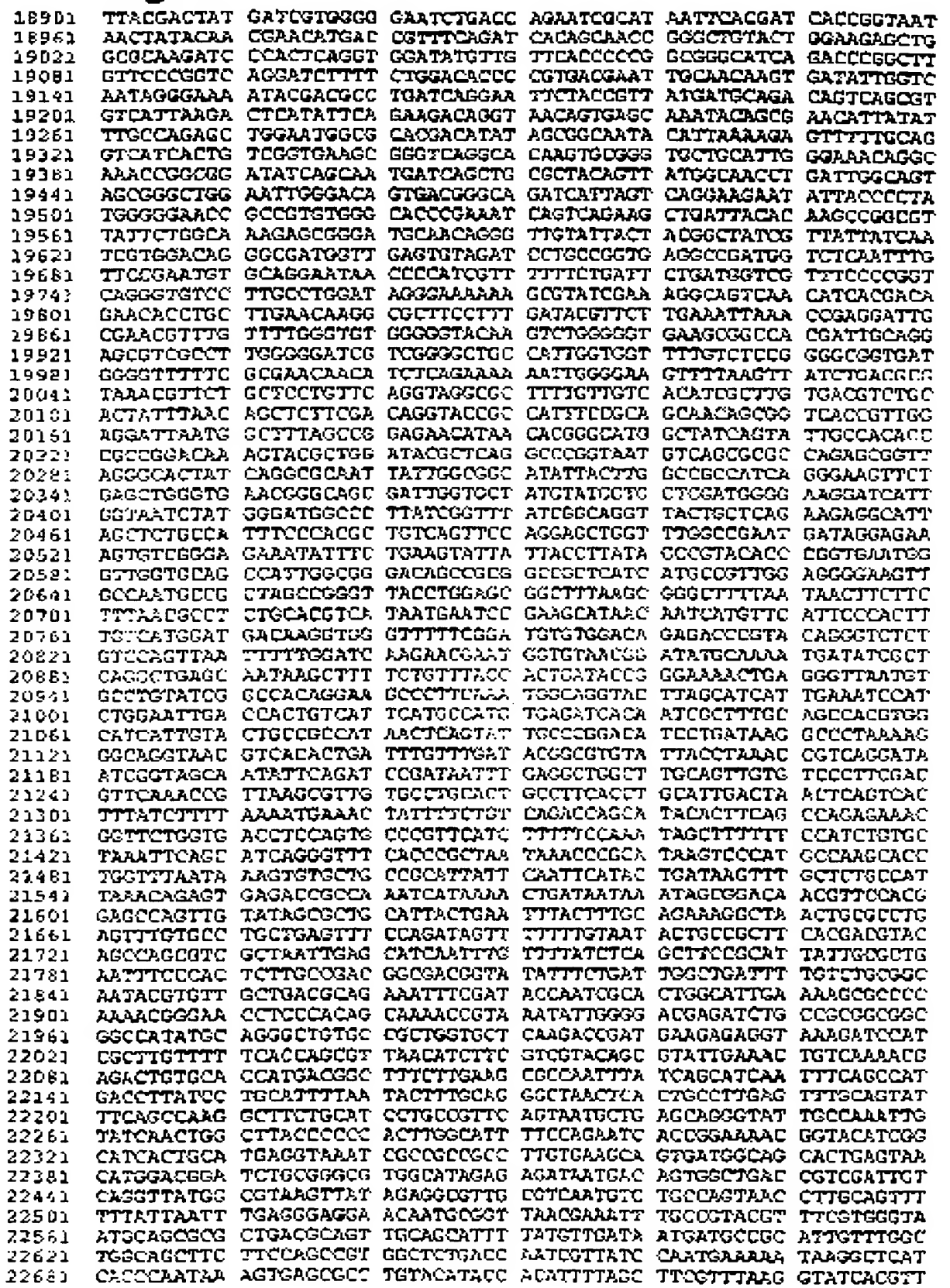

Fig.2.

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Fig.2.

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29401 GAATATAGCC CCGCACTCGC GGGGTTTTTT GCTTTCTGGG AGTCGGAAGT TTAACCGTAG
29461 TGACGAGGAT CAAAACTAAG TTAACGGCAG TGGTCACTGA TTTGGTGCAT AAGTTATCAA
29521 AAGTTAAAAA TCAAAACTTA TTTTTTATTT AATAGAGGAA TGTCACCCTG TAGGTGAATA
29581 ACGTTGACGG ATGTAAATAT ACAGTATTAT AGTCCTTTGA TATGTTATTA AATTGAAAAA
29641 CCTTTAAACT ATATTCGGGG GAAATTATTA TGTCAGATGT TCGTAATATT ATTAATGTTG
29701 ATAACAATTT TGGTTGTGAA TATAAAGCGG ATTTATTTAA ATAAGTTTTC ATAATTGTGA
29761 TACACCCATT TTTCTCATCC CCGGTTTTTG CTGTTGTAAG GAAGCGGTTT CCATGAAGAT
29821 TTTGACATGG TTAAGCAACT GCCACATAAA TTGGCAGCAG TGGTTTCGTG TCACGGTTTC
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29941 GAGAAGATTA AATTTGGGAT TCTTTGCCAG CCAAACCCTG ACCTTCCGGC TCTTATGAAT
30001 GCAATAGTTA TCTAAATTTA ACGTGATGGT TTTGGCATTA ACATATTTGA TGTTAATTTC
30061 ATCTAACAAT TTGATAAATA AATCTGAGTT CTTTCTCAAG CTACCGACAT AAGTGATTTC
30121 TTTCGTTTTC GCGTTGAGGC AATTGGCAAG GTAGTGTTTT TGGTTCTTTC CGGGGGTAAC
30181 AACACGCTTT TGTTGCCCTT TGAAGCACCA GTCTGCACCG ATTTTCGGGT TCAGGTTGAT
30241 GTCCACCTCA TCCTCATAGA AGACCGGGTG TTTCTCTTGA GGCATTGGAT AACGTCTCCC
30301 TGATTTTTGC CATTTTTTCA TCATACTCAG GGTCAGGCAA TTTTACGGTT GGTGCCGCCC
30361 TTCGCCAAAC GATGCCCGTC CGGCAAAAGT AGCGATAGAG GGTACTTTGA GAGAGCGATG
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Fig.2.

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30541 AGTTCCAGAT GGCAGGCCTT CCCGCCGGGA GGCTTTTAAG TCCTTCCAAC CCGTATAATG
30601 TTAACCAATT TACCCAACGA TGAACGGAAG AAGGTGAACA GTGAAGCGTT CTGGAAACGT
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30721 TATCCCGGGT TTTCTGGATA GCTTTTTTCA TCGGACGTCG TTCATTTCGG GGTATTGATG
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30841 CGCGAAAATC GGACTGAGTT CCCTTCAAGT GATCTACTAT TTTGAAATCT TATTTAATCA
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30961 TGATTCATCT ACCGGTGGTA TGTGGATTCC TTGGTGCGAT AGTCAGAAAG ATATTGACTC
31021 TGGCCATTAT ATCAAAGTTA CTTTCAGTAA AAAGGACGCT GCTGATATTG TGAACTACAT
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31441 TAACAGAAAA TTCATGGTTA GGAAATTCAA TCAACTTTTG TCCGGTTTCC TGACCATGAA
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31561 GTCAGCAGAT AATATGTTGT ATATTGGCTG TGGATTTTTC AGCGAGATGA TAGCTTTGGC
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31741 TTTTATCCCT TTATCTGCCG GAAGCGATCC GGTCAGTGTG TGATTTACCA CACTAAAACT
31801 GGAACCGGCA GCTTTGTGGA CAGGCAATTA CGTCAGTTGC ACAGTGATGT GCTGTATTCT
31861 GTCGAGACAA CCCACGGGGA CGGTTACATT TATTCCCTGA TTGAACACCA GTCCACGCCT
31921 GATCCGTTAA TGGCCTGGCG GCTGATGTAT TATTCGCTGT CAGCCATGGC TGCGCATCTG
31981 AAAAAAGGAC ATACTGAACT CCCTTTGGTC GTCCCCCTGC TGTTTTATCA TGGTGAGGTG
32041 AGGCCTTACC CTTACTCAAA TCGATGGCTG GATTGTTTTA CACTCTCTGA ACACGCGGCT
32101 CACCTGTATA ATCAGCCCCT GCCGTTGGTG GATATCAGTG CGCTCAGTGA TGAAGAGATC
32161 CTGACACATA AAAGCATTGC CTTGATGGAG CTGGTACAAA AACATATCCG TTGCCGGGAT
32221 ATGCTGGAGT GGGTTCCCCA ATTGGTGGCG TTGTTGAATG CCGGTTATAA TAGCGCCGAA
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32341 TTTGTCCATC AACTGACTGA ACAATCTCCG GAGCATGAAA CCATGTTGAT GACTATTGCA
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32761 CGTGAGCAGC ATTTGCCAAC AGGCCATCAT CCTGATCGCC TGACCAAGAG AAGATCCCGC
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32881 AAATCCAGTG ACCACCGTCA GCATTAAAGA GTGCGTCAGC GTCGGTTTCC GTGTCTGTCA
32941 CCAGTTCAAA CTGATTTTTC CCGCGTGCAA TTTCATATTC CGCATCGTAT TGGTTATTCA
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33121 GGTGAATTTT CTCCGGTTGT ACACCTTGTG ACAGTAAAAA GCGGATCGCC TCATCTGCCG
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33241 TGGGGGGATA CAGGTTAGTA TGGTGACCGA TGTATTCTGC CCAACCGGTA CCAAAGAAGT
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33361 CCATTTTGGC AACGACGGCG CTACAGGCTA TCGTGATTTC TTTACGGGCC CGGGTTCCAA
33421 AGGCGATGTT CAGTGCTTCA CGCAGCTCTT TCACTAACAA AACATAGTTT GGGCCATCAT
33481 GTTCCGGGTC GAATTCATTA CCTTCTTCAC CTGTGGCGCC GGGGTATTCC CAGTCGATAT
33541 CCACCGCAGT AAACATGGGA AAACGCCGGG AAGAAGTCGA CGATGCTACT CACAAATGTA
33601 GCACGTTGCT CAGGATCTTT GGCCATCACA GAGAAATACC CTGACATACT CCAGCCGCCG
33661 ATACTGAATG CGAGTTCCAG CTTATGCCCT GCCTGTTTTG CTCGCGCTTT CAGATTACGC
33721 AATCCCCCCA GTAAACCGGA GGCTGCATCC TGATTGTAAT ATTGCAAGAA ATTCTTCGGG
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33841 TAAGGATCAA CGGGTACAAT ATGGCCTAAT GTAATAGGGG CAATCTGGCC ACTGCTGGCT
33901 TCTGCTTGCC GGTTCCACCC GTCAACAACC TCATTAATCC GTTCGGATAA CTTGCCTTTG
33961 TCACCGTTGA CGGCCATAAA ACTGAAAATC AGGCGGTCGT AGGCGGTAGG CGGGATTTTT
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34141 AGCGGTTCTG TATTTTCCGG ATCAACTTCA TATTCGTTGT ACAGGGACTT GGCAACACGT
34201 GCTGAAGAAT AACTCAAAGG AGTTCCGCTG CCGTCAGCTT TATATCCCAC CTTCTGATAG
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Fig.2.

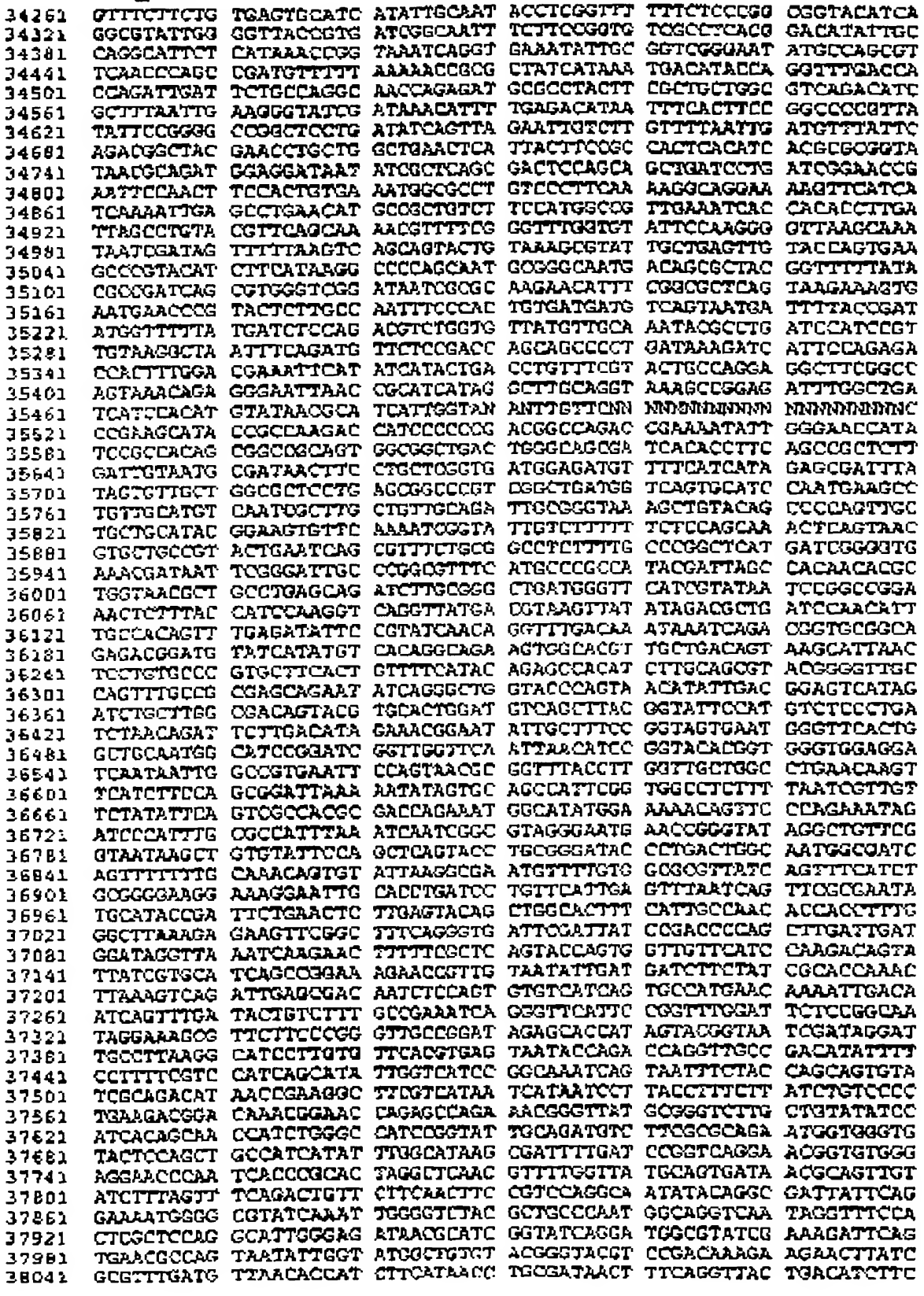

Fig.2.

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38101  AAAATTATTC AGATAACCGA GCACCGCTTG TTGTACAGAA TCTTCGGTAA TTTTTCCCTG
38161  ATTAAGGGCA CTTTCCAGTT GGAAGAAGAA TTCTGTTTTA TTCAGGCGTA ACAGGGGTTC
38221  CAGATAGCTT TCCGGATAAG TCCGTAATAA GCGATCCC
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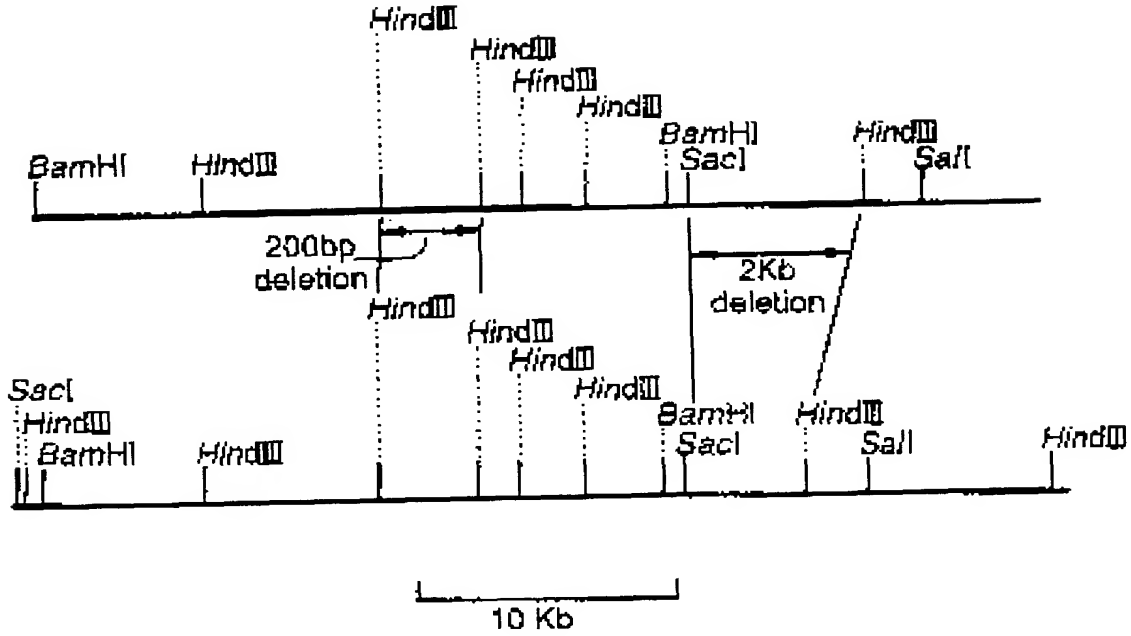
N=unspecified base

Fig.3.



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